IDENTIFYING GREEN LOGISTICS BEST PRACTICE LEADING TO THE EFFICIENT MANAGEMENT OF RESOURCES AND WASTE IN THAILAND’S PUBLIC HOSPITALS

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Abstract

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Keywords: Green Logistics Adoption, Thailand's Public Hospitals, Sufficiency Economy Philosophy, Sustainable Development.

The aim of this study is to identify green logistics (GL) best practice leading to the efficient management of resources and waste in Thai public hospitals. This work is influenced by and is aligned with the Thailand's 2nd National Logistics and Supply Chain Research Strategies (2012-2016). The GL practices of six public hospitals were investigated, chosen to give coverage of the different types/sizes, locations and a range of environmental performance issues. Hospital visits were undertaken to collect data by interview, documentation and observation approaches. The GL best practices were principally identified by using developed indicators and a cross-case analysis method.

The results of this study showed that resource and waste flows appeared very complicated within Thai hospitals. Thus, effectively introducing and managing GL within these settings requires the coordination of all staff (clinical and other), and the consideration of all environmental impacts from product purchasing through to waste disposal. Many beneficial practices for successfully reducing resource consumption and waste were identified. Key findings were that green initiatives need to be supported by: sufficient environmental education; two-way communication; effective evaluation and recording systems; and Director-level support. Importantly, GL adoption in the Thai context should be grounded in the Sufficiency Economy Philosophy concept (e.g. moderation, wisdom, and happiness), as well as contemporary hospital logistics theory and practice. Finally, it is recommended that the current Hospital Accreditation process is changed to integrate sustainable best practices, and that some pertinent government regulations and policies should be reviewed and changed as they were seen to be counterproductive and indeed in many cases it was proven that the enactment of the policies themselves actually increased waste.

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Lastly, I am indebted to my family: my father Chingchai Bandoophanit, my mother Wanida Bandoophanit, and my older sister Chorward Bandoophanit. They were very caring and supportive during this PhD course. This thesis from its completing onwards is dedicated to my family, Thailand and our King, and the Buddhist religion.

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Key Glossary

BAAC	Bank of Agriculture and Agricultural Cooperatives, Thailand
CSCMP	Council of Supply Chain Management Professionals
DOH	Department of Health, Thailand
E-Logistics	Electronic Logistics
EMS	Environmental Management System
ESC	Environmental Science Centre, Augsburg, Germany
EU	European Commission
FIFO	First-In First Out (or First expired, first used – Thailand)
GL	Green Logistics
GPO	Government Pharmaceutical Organization
GSCM	Green Supply Chain Management
GW	General Waste
HA	Hospital Accreditation
HCWH	Health Care Without Harm
HEM	Hospital Environmental Management
HW	Hazardous Waste
IW	Infectious Waste
ISO	International Organization for Standardization
JIT	Just-in-time
LCA	Life Cycle Analysis
MOE	Ministry of Energy, Thailand
MOPH	Ministry of Public Health, Thailand
NESDB	National Economic and Social Development Board, Thailand
NHS	National Health Service, UK
NHSO	National Health Security Office, Thailand
NRTC	National Research Council, Thailand
NSO	National Statistical Office, Thailand
NSTDA	National Science and Technology Development Agency, Thailand
OECD	Organization for Economic Cooperation and Development
PCD	Pollution Control Department, Thailand
PTT	Petroleum Authority of Thailand
RL	Reverse Logistics
SD	Sustainable Development

SEP	Sufficiency Economy Philosophy
SS	Sustainable Sufficiency
TGP	Thailand Government Procurement
TRF	Thailand Research Fund
UC	30-Baht Universal Coverage Scheme, Thailand
UN	United Nations
UNCSD	United Nations Conference on Sustainable Development
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and and Cultural Organization
UNSD	United Nations Sustainable Development
US EPA	United States Environmental Protection Agency
WCED	World Commission on Environment and Development
WHO	World Health Organization

Chapter 1: Introduction to the Study of Green Logistics

1.1 Introduction

This section principally discusses “what is the topic?” and “why is it important?” For that reason, the research aim, motivations, objectives, questions, gaps, contribution and structure are explicitly provided.

The principal aim of this research project is:

‘To identify Green Logistics best practice leading to the efficient management of resources and waste in Thailand’s public hospitals’.

Among the upper middle-income countries, Thailand has been identified by various authors such as Gottret et al. (2008) as a good performer in health financing reforms, that is the ‘Universal Health Coverage Scheme’ (30-Baht scheme or UC scheme). In contrast, more than 70% of Thai public hospitals have suffered under this scheme, generating financial crises, poor healthcare services and operations, and scant workforce (NaRanong and NaRanong, 2011). Hu et al. (2008, p.1851) summarized that “In the Thai case, some facilities ended up with shortages, whereas others were over-financed due to registered patients”.

Additionally, the poor logistics and environmental performances of Thai public hospitals are widely criticised (e.g. Singkarin, 2009, Singkarin, 2012, PCD, 2013c). These include poor infectious waste management, overuse of medicines and medical supplies, and low integration of information systems. Such problems greatly affect the quality of medical services and the health of Thai people.

Performance can be improved by considering the adoption of Green Logistics (GL) within these settings (e.g. Sameer et al., 2008, Dey et al., 2011, NHS, 2013). GL is a specific tool to effectively manage the environmental impact generated in all logistics activities in the cycle of a product’s life (from purchase to waste disposal). Integrating GL in the healthcare industry, especially Thai public hospitals, has been under-studied. This area is recommended for investigation by the 2nd National Logistics and Supply Chain Research

Strategies (2012-2016). The research project described in this thesis has the potential to help many Thai hospitals successfully implement GL practices.

Hospital practitioners should clearly understand their key logistical flows, which are patients, resources, waste, information and finance. This helps to realize the life cycle of resources and waste, in order to better control environmental impact and improve logistics performance. During this project it became apparent that "Sufficient Economy Philosophy" (SEP), the applied Buddhist concept, could have a significant role to play in improving the environmental impact and overall performance of Thai hospitals. This is discussed in depth later in the thesis.

At the outset it was intended that this project should cover all aspects of GL related to the operation of hospitals. During the research it became apparent that this was too wide a scope so this project focuses on the "internal logistics processes of hospitals in Thailand".

1.2 Research Questions

The main research question is ***"What are the Green Logistics best practices leading to the efficient management of resources and waste in Thailand's public hospitals?"***

To answer this main question, five sub-questions have been formulated:

1. **What are the most important study areas in Thai public hospitals?**
2. **How should we measure the GL performance of Thai public hospitals, in the areas identified in 1?**
3. **Which Thai public hospitals are performing best on each measure?**
4. **What practices are allowing Thai public hospitals to best perform?**
5. **What are the barriers to addressing environmental programmes in Thai public hospitals?**

1.3 Research Gaps

GL adoption is a relatively new research area, thus several areas are under-investigated and appear to be weak, such as GL implementation in developing countries (see section 2.6, Table 2-2 and Appendix 2). This could be one of the key factors that affect the GL adoption rate. From the literature review the following research gaps have been identified:

i) Undertake research to take a holistic (or whole process) view of best practice adoption. This needs to cover; performance measures; identification of best practices; strategy development; identification of barriers to implementation and effective implementation strategies (e.g. Lau, 2011, Lin, 2011, Tacken et al., 2011, Chaisurayakarn, 2013).

ii) Analyse life cycle of products to realize eco-aspects (Beamon, 1999, Dekker et al., 2012)

iii) Examine GL adoption in developing countries (Thiell et al., 2011), other industries apart from those dominated by logistics, and small and medium-sized enterprises (SMEs) (Yacob et al., 2012). The public sector also needs more attention. These areas lack knowledge and/or resources, but produce a large amount of environmental impact.

iv) Highlight human-based elements such as environmental awareness, education, and community involvement (Lin, 2011, Choi and Zhang, 2011), rather than focusing on only physical elements.

v) Conduct onsite observation of logistics movement in person, and fieldwork study and mixed methods, in order to identify best practices and allow data triangulation (Aronsson and Brodin, 2006, Ubeda et al., 2011)

vi) Better reflect the current phenomena and solve problems, more coordination with organizations and collecting data from all staff rankings and logistics-related departments (Ubeda et al., 2011, Choi and Zhang, 2011).

vii) Examine other areas besides transportation and carbon dioxide reductions, such as stocking, waste management, and resource over consumption.

viii) The concept of sustainable development has several weaknesses, particularly an over-focus on economic factors (UN, 2010, Netzer, 2012). This may be replaced by considering other philosophical concepts such as sustainable sufficiency (Welford, 2000, Lamberton, 2005).

ix) Measure the results of GL adoption by evaluating four areas: logistics, finance, environment and social relation, instead of focusing only on logistical efficiency and cost reduction (Punpeng, 2011).

Understudied Areas of Thai Hospital Green Logistics

The 2nd National Logistics and Supply Chain Research Strategies issued by the Thai government (2012-2016) principally suggested studying and developing models or practices to guide GL in Thailand's healthcare industry.

A noted difficulty with this agenda is *'How do we simultaneously improve performance of both logistics and environment in Thai public hospitals?'*

These two areas are currently challenging. Improving logistics efficiency is obstructed particularly by the government systems/policies such as use of a paper-based system, several approval processes, and low budget allocation for operational development (e.g. Singkarin, 2011, NaRanong and NaRanong, 2011), whereas environmental management is relatively poor due to practices such as mixed waste, and overuse of medicine and utilities (Sumpradit et al., 2012, PCD, 2013c). The Thai government has developed an environmental initiative "GREEN and CLEAN" but it is limited in its scope, evaluation processes and effectiveness. This may indicate the need for restructuring all logistics, regulation, and environmental systems in order to meet the national agenda. This presents a great opportunity for this research project and challenge to those implementing GL in Thai hospitals.

1.4 Research Contributions

The key research contribution of this project is the combination of linking effective strategies to the map of internal logistics flows in Thai hospitals. These strategies promote efficient product consumption and waste reduction as well as strategies for the hospitals and government to support GL adoption. The recommendations cover physical practices, implementation practices, and policy/system development (see Chapters 5 and 6).

Physical Practices

These practices identified 'How the hospital effectively reduces the resources used (e.g. medicine and electricity), and waste generated (e.g. infectious waste).

Implementation Practices

The study has discovered close linkages between the government, the hospital Director and hospital employees which are mostly one-way communication or refer to a highly-developed hierarchical system. Therefore, open communication and close coordination are needed. To implement GL first requires education on GL and SEP for the Director, since this person can make decisions on adoption, budget allocation and resource provision. Subsequently, all employees should be well-educated in the policy introduction. An environmental team should be assembled to monitor and evaluate overall environmental performance, and sub-teams to monitor key areas e.g. medicine and electricity. Sufficient support to all hospitals should be delivered by the government, including financial, knowledge, technology and human resources.

Still more effective indicators and evaluation systems are needed. Since the effective use of GL practices is very beneficial to the hospital, they should be included in the Hospital Accreditation (HA) system which dictates their compulsory enforcement. Several challenges that affect GL performance are highlighted in Chapter 6.

1.5 Thesis Structure

<u>Chapter 2: Reviews of Green Logistics at Global Level</u>

To understand what has been done in previous research, this chapter addresses the key themes/topics within and related to GL. These include the green supply chain, reverse logistics, environmental management and sustainable development. The literature was reviewed from cross-disciplinary sources and examined for key elements such as definitions, practices, drivers and barriers to adoption of GL as a philosophy and practices. It also discusses frequently-used methods and research outputs of previous studies. Later, this chapter provides a number of research opportunities for conducting GL research at global level. It narrows down to the focus on studying GL adoption of the public sector in a developing country which finally explains the selection of Thailand healthcare as a case region and case industry respectively.

<u>Chapter 3: Reviews of Green Logistics in Thailand Hospitals</u>

This chapter seeks to understand current logistical operations and environmental management systems (EMSs) of Thai public hospitals. Since such knowledge was limited, it is supplemented by international sources of data, such as the World Health Organization (WHO) and UK National Health Service (NHS). A review of current Thai hospital practice to confirm the need for the research and guide its focus was undertaken (henceforth, this review will be called 'THP Preliminary Study'). Interviews were conducted with nine Thai hospital personnel to gain insight into present hospital logistics and EMSs. The results generated led to the development of a generic hospital logistics diagram (Figure 3-4) to clearly show key logistical movements (e.g. patient and resource flows). This also reconfirms the most significant study area to be explored, i.e. seeking ways to minimize resource and waste, together with improving logistical performance. Lastly, the THP Preliminary Study provides targeted guidance for personnel involved in interviewing and implementing GL policy or conducting further study.

Chapter 4: Research Methodology

This chapter shows how the author approached the study at hand and the logical steps taken to achieve the research goal (aim) and answer the research questions. It starts with providing an overview of the research design, followed by a description of how the data was collected using a multi-method approach: interviews, documentation reviews and in situ observation. Later, it presents the process of analysis which is used to identify best practice. Cross-case analysis and a diluted form of content analysis were principally used (see Chapter 4, section 4.5). Research indicators were developed for identification purposes.

Chapter 5: Data Analysis and Discussions

The purpose of this chapter was to analyse the data collection which led to the identification of the most effective GL practices as demonstrated by the respondent sample. The background of six case hospitals was firstly reviewed and presented; as this information was key to understanding GL adoption performance. Practices were grouped according to key hospital resources or waste (e.g., medicine, electricity and infectious waste). Later, the discussion focuses on the best practice (physical practice) that uses the least resources, or generates the least waste/impacts or is replaced by the greatest volume of green product. Following this, the question ‘What makes them (the Hospital practice) so successful?’ is asked or ‘Why did they fail?’, which leads to a discussion on implementation factors.

Chapter 6: Recommendations and Conclusions

This chapter focuses on the most important environmental aspects of the hospital. It develops the discussions from Chapter 5, to recommend the most effective and practical GL practices (see Tables 6-1 and 6-2). They are grounded in the SEP concept and the basic hospital logistics flows (Figure 3-4). Additionally, all hospital features, success factors and potential barriers are considered. This chapter also addresses **‘How government can support or strengthen above practices’**, and **‘How future research contributes to the body of knowledge.’** The chapter is presented largely as a practical guide drawing on the academic discussion and conclusions from Chapter 5.

1.6 Diagrammatic Thesis Structure

A ten-step thesis structure can be mapped out as Figure 1-1 below. This research project starts by conducting a literature review of GL at global level; it then moves to examine research into GL in developing economies, before focussing directly on GL in the public sector and more specifically on the Health Sector in its entirety (Chapter 2). This identifies the key research gaps confirming the need for more research in GL in the Health Sector in developing economies. This leads to the adoption of the research methodology which involved the exploration of GL implementation policies in public hospitals in Thailand, as a case organization and region respectively. This is according to the need stressed by the Thai national research strategy (Chapter 3).

This strategy requires Thai researchers to deeply understand the healthcare context (e.g. logistics, environment and culture), in order to develop a model or practice to guide effective GL adoption. But since this knowledge is limited, a review of the current status of GL in Thai hospitals was conducted to help to focus the research. It revealed a lack of consistent understanding of the current environmental policies and highlighted the key areas where research was needed to develop best practices to improve resource usage and reduce waste without having a detrimental effect on patients.

Chapter 4 sets out the research design, the research boundaries and tools (e.g. indicators and interview questions) to collect data at the target hospitals, as well as the analytic methods including content analysis, thematic analysis and cross-case analysis. The content analysis was a basic form not using computer software and coding. The data collection took place in six hospitals chosen to reflect the range of operating characteristic of Thai hospitals. In the analysis, Chapter 5, data was reviewed, focusing on their ‘content’ and regrouping once again according to key major themes or sub-themes. During the analysis, some interesting and unexpected issues emerged. Although this brought further studies to update/edit a small part of the literature (Chapter 3), this is not affected by the original research objective. Chapter 5 highlights all best GL practice, and barriers to their adoption. The last chapter, Chapter 6, selected only key recommendations for practitioners, governments and future research.

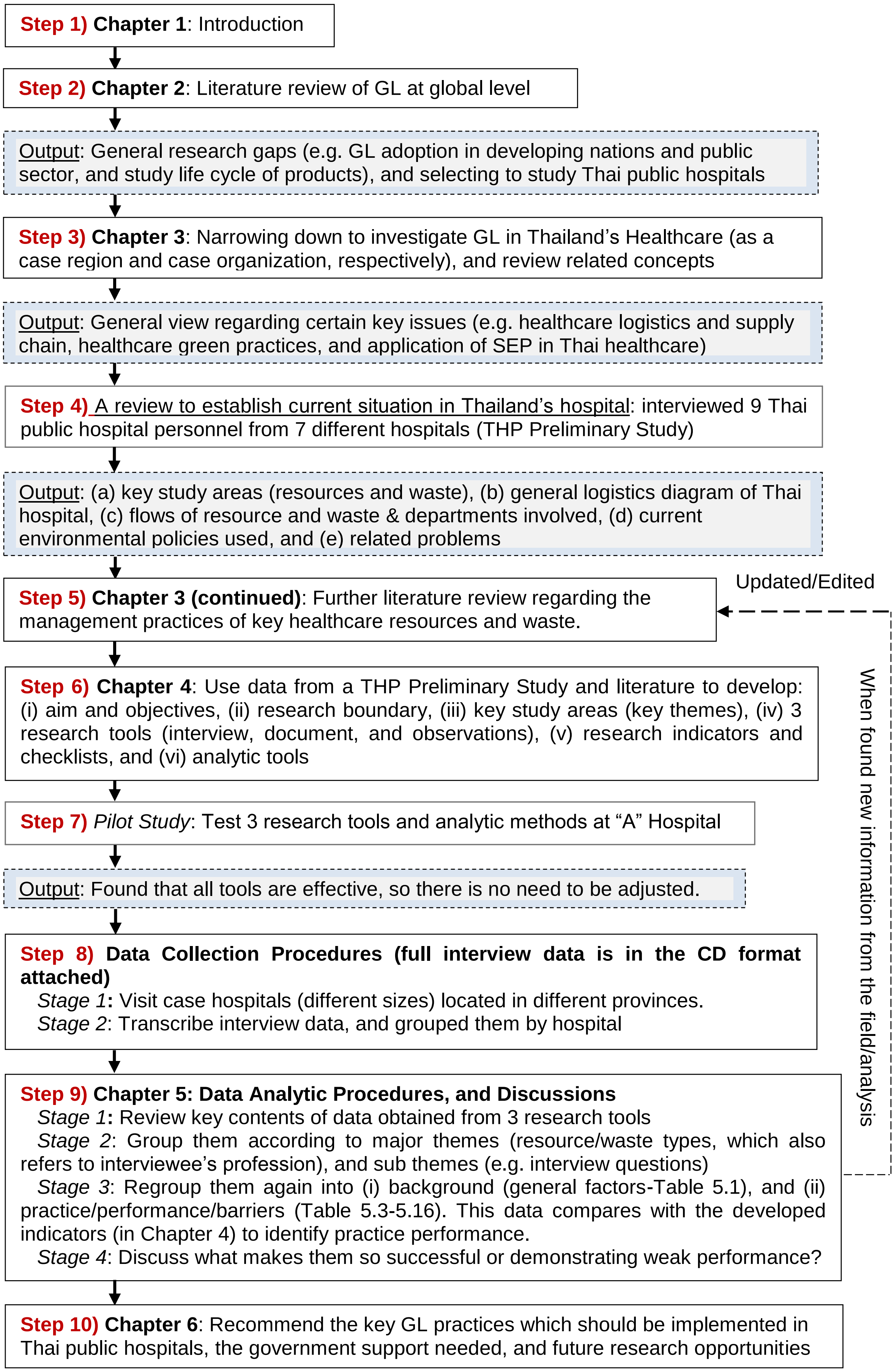


Figure 1-1: Diagram of thesis structure.

1.7 Research Motivations and Conclusion

The motivation to conduct this research was the growing negative environmental impact of hospital logistics operations, whether by overusing resources, mismanagement of waste, or poor logistics systems. This has significant impact on the quality of medical care delivered to more than 90% of Thai people. The situation is getting worse as most public hospitals have limited knowledge and budgets, high workloads, and insufficient government support (e.g. Ngorsuraches and Attapon, 2006, NaRanong and NaRanong, 2011, Ariyasriwattana, 2012).

This is a very interesting area to investigate. The key contributions of this study are the recommendations, which offer guidance to Thai hospitals governing GL practice adoption and application. This can enhance operational sustainability leading to more efficient resource allocation, waste reduction and GL management. The recommendations also provide evidence-based results which can be utilized by the Thai government to fully support hospitals in effectively managing internal hospital logistics to meet government agendas such as GREEN and CLEAN, hospital environmental accreditations, and sustainable society.

Chapter 2: Review of Global Green Logistics Studies

2.1 Introduction to Global Green Logistics

The growth of logistics functions such as transportation, warehousing, inventory control and e-logistics, to support national development, has generated unwanted environmental impacts such as energy and resource depletions, air pollution and waste generation (McKinnon, 2010). Addressing environmental management (EM) within logistics, ‘Green Logistics’ (GL), is perceived to be the solution to achieving sustainable development (SD) (Ping, 2009, Lai et al., 2012).

In the academic world, GL studies have appeared in several fields of operations management such as green supply chain management (GSCM) (Xie and Breen, 2012), logistics (Poist, 1986), manufacturing (Lai et al., 2012), transportation (Gross et al., 2012), and environmental management systems (EMS) (Zhu and Sarkis, 2004). Thiell et al. (2011) categorized GL as a new research area which Lin (2011) claimed was virtually non-existent prior to 1990. This was the same time as ‘greenness’ became a catchword according to the United Nations (UN) promoting SD (McKinnon, 2010). Murphy and Poist (2000) and Lin (2011) viewed GL as a relatively young but rapidly evolving subject. Lin (2011), hence, concluded that there are several research areas of this new discipline that are unclear, lacking knowledge and poorly understood.

The purpose of this chapter is to undertake a literature-based review of GL and its related study areas, including sustainable development (SD), environmental management (EM), logistics/ supply chain, green supply chain management (GSCM). As Lin (2011) and Thiell (2011) state that GL has now existed for two decades, literature within this time frame was chosen for review. Various authors assert that adopting green practices is a complicated process requiring cross-discipline coordination involving human elements (e.g. commitment, awareness and cultural change) and physical elements (e.g. new clean technologies) (Russo and Fouts, 1997, Lin and Ho, 2011). The literature was consequently reviewed from cross-disciplinary sources and examined for research patterns and key elements such as definitions, practices, drivers and barriers to adoption of GL as a philosophy and practice.

2.2 The Original Sources of the Green Logistics Concept

From the above sections, four major concepts which are the original sources of GL were apparent, namely: (i) sustainable development (SD), (ii) environmental management system (EMS), (iii) logistics/supply chain and reverse logistics, and (iv) green supply chain management (GSCM). The purpose of this section is to review GL from these cross-disciplinary sources for a better understanding of its development, and designing the research boundary.

2.2.1 Sustainable Development (SD)

"The day when environmental management and economic development seemed to be in conflict has to be put far behind us".

Dr Gro Harlem Brundtland (WCED, 1987, p.5)

<u>Sustainable Development Concept</u>

Sustainable Development (SD) is a global agenda for change published in *"Our Common Future",* (WCED, 1992). The aims are halting pollution and ending the destruction of irreplaceable natural resources (UN, 1997). The classic explanation of SD was defined by the United Nations (UN) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The UN had made some progress, such as the Kyoto Protocol in 1997 which attempts to reduce greenhouse gases (GHG), mainly carbon dioxide (CO_2) (UN, 2010).

Although the UN's basic idea is to balance three pillars (economic, social and environmental), evidently these pillars are imbalanced, consistent with capitalism (Welford, 2000, Lamberton, 2005). Several strategies of the UN are likely based on economic views, such as carbon credit, green economy and using the maximization of welfare (Rogers, 2000, Netzer, 2012). Likewise, various economic indicators have been adopted to measure the progress of SD such as Gross National Product (GNP) (UN, 2012a). The existence of SD is largely critiqued, because of barriers like low understanding of the concept (Göçer and Tuna, 2013, p.2), and using fragmented approaches that cannot provide a holistic view of SD (Barber et al., 2012). However, the UN (UN, 2010, p.3) claimed that only two decades of SD establishment are too short to have a positive structural change.

Replacing Sustainable Development by Sustainable Sufficiency

Dr. Bruntland, head of the commission who developed the SD concept, maintained that the main causes of world environmental degradation and greenhouse effects were poverty, population growth, poor education, nuclear war and unintended development (WCED, 1987). Are these the real causes of environmental issues?

Sustainable Sufficiency (SS), a Buddhist economic philosophy, argues that the above relationships are too simplistic. The real root causes of resource depletion, climate change, sustainability issues, etc. are human greed, power, and the wealth of governments and companies (Boyce, 1994). Lamberton (2005, p.61) defined SS as, *"achieving economic objectives consistent with the principle of right livelihood, ensuring the preservation of the natural environment and the welfare of each individual and society-at-large"*.

So, what is the real concept of sustainable development as understood by the UN? Regarding the exploitation of resources such as forests, the UN has commented that these may be depleted to support economic development, which is not a bad thing if it has been planned and taken into account (WCED, 1992, section 11).

Schumacher (1973), the father of Buddhist economics, rejects the greed and materialism on which so much of modern economics is based. He asserted that resources should be used to satisfy only essential needs, so SD should be based on moderation – as the basic approach to development planning (Schumacher and Schumacher, 2011). Given that greed is the main cause of unsustainability, only education to enhance *"morality"* can be the solution (Payutto, 1995). Mindfulness practice can be a crucial step toward ending excessive consumption, because we can identify our true needs (Plum Village, 2013).

Some Buddhist nations have effectively applied SS to their national agenda, such as Bhutan with its ‘Gross National Happiness (GNH)’ and Thailand’s ‘Sufficiency Economy Philosophy (SEP)’. SS is hence viewed as the new ethical paradigm for sustainability. Obviously, it is indicated that SS rarely appears in these areas: non-Buddhist nations, industries including logistics, and organizations/institutes that have already addressed SD. Hence, their integration with SS is questioned, particularly the feasibility, strategy and measurement systems used to support implementation. Welford (2000) claims that this Buddhist principle can even be extended to enhance sustainability in western economic practices.

After SD was introduced in 1992, in 2012 the UN Secretary General (Ban Ki-moon) stated the need for a new economic paradigm that recognizes happiness as a measure of national well-being instead of GDP and so on (UN, 2012a).

Note: SEP will be discussed later in section 3.1 (vii – viii).

2.2.2 Environmental Management System (EMS)

<u>ISO 14001: Helpful Standards for GL Adoption</u>

To date GL as a discipline does not have its own management practices to guide effective adoption and evaluation (Thiell et al., 2011, Tacken et al., 2011, Lai et al., 2012). EMS-ISO14001 is recommended by GL scholars such as Rogers and Tibben-Lembke (1998) and Beamon (1999). The reason given is that ISO14001 was designed to address these needs for any entity and for every size of firm, regardless of whether or not organizations intend to achieve certification. Also, several nations such as Thailand, Japan, Canada and Australia adopted EMS-ISO 14001 to guide the GL adoption (Japan Ministry of Land, 2006, Metro Vancouver, 2009, Australian Government, 2012, PCD, 2013a). ISO 14001 is perceived to guarantee certain benefits, including energy and materials saving, cost reduction and improved corporate image (US EPA, 2013). There is another kind of EMS called Eco-Management and Audit Scheme (EMAS), but no strong evidence suggests its use.

What is ISO 14001 standard?

ISO 14001 is an environmental management standard developed by the International Organization of Standardization (ISO) (ISO, 2011). This cornerstone standard of the ISO 14000 series[1] contains five essential elements: commitment and policy, planning, implementation, evaluation and review. By following a Plan-Do-Check-Act concept, this cycle repeats results in organizational improvement. In detail, ISO 14001 comprises of 17 elements for formally addressing EMS such as an environmental policy supported by senior management and identification of environmental compliance (see Figure 2-1).

Beamon (1999), Wu and Dunn (1995) and Dekker et al. (2012) suggested considering 'Life Cycle Assessment' (LCA) through: (i) the way they have been produced (their carbon footprint), (ii) the way they have been transported and are waiting for use, and (iii) whether their value can be recovered after their use. Thus, the minimization of the firm's total environmental impact is achievable.

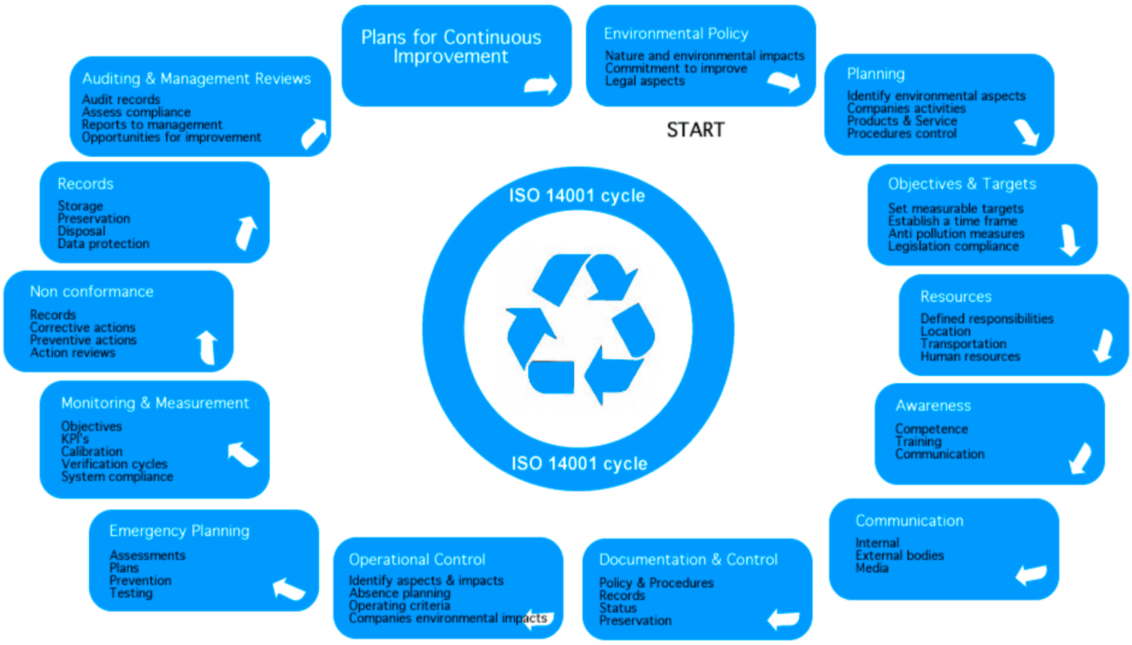


Figure 2-1: ISO 14001 processes.

Source: ACS Registrars (2013).

[1] (i) Environmental management systems (14001, 14002, 14004), (ii) environmental auditing (14010, 14011, 14012), (iii) evaluation of environmental performances (14031), and (iv) environmental labelling (14020-14025)

2.2.3 Logistics/Supply Chain and Reverse Logistics (RL)

Differences of Supply Chain and Logistics

From the introduction of this chapter, GL study has emerged in the logistics and supply chain school of thought. Thus, it is very clear that the above are the fundamental concepts of GL that will be investigated here.

"Supply chain" starts with unprocessed raw materials and ends with the final customer using the finished goods (CSCMP, 2013b). Hence, it links all units in the chain together such as manufacturers, vendors, logistics service providers and customers.

"Logistics" was defined by McKinnon (2010, p.3) as "*the transport, storage, and handling of products as they move from raw material source through the production system to their final point of sale or consumption*". Hence, the logistics activities often involve inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service (CSCMP, 2013a). The logistics activities defined by CSCMP have been considered and used in this thesis, because this professional organization is highly accepted (Rogers and Tibben-Lembke, 2001, Singkarin, 2012)

In addition, logistics can be divided into two perspectives: (i) internal logistics the boundaries of which are within the walls of an organization, and (ii) external logistics which involves external parties (e.g. suppliers and customers) (Jonsson, 2008).

The research focuses on internal logistics and green practice within an organization. This approach has been deliberately chosen based on many authors concurring that it is more effective to manage environmental impacts from existing logistics functions rather than establishing and integrating green practices in the supply chain (see also section 2.2.4).

Key Requirements of Logistics Functions

As mentioned earlier, logistics comprises many activities starting from raw material sources through to the final point of sale or consumption. Good quality logistical operations rely upon cost reduction, speed, flexibility, timeliness and service reliability (Thiell et al., 2011, Rodrigue et al., 2013). Consequently, effective logistics favours shorter shipment, less handling, more direct routes and minimal energy consumption (Wu and Dunn, 1995). Addressing the new GL practice should support these purposes. Examples of inefficient logistical practice include poorly used storage facilities and unnecessary product movement, all of which are unsustainable because of increasing resource consumption and pollution (Montreuil, 2011, p.5). Some key logistics concepts have emerged as follows.

Key Logistics Concepts

'Freight villages (FVs)' is a new generation of GL and GSC, which has emerged world-wide. FV clusters, e.g. manufacturing and trading companies, intermodal terminals, gas stations, and logistics facilities located in the same area (Wu and Haasis, 2013). This enables transferring freight from one mode to another generating fewer negative environmental impacts, because of, for example, reducing urban congestion.

'Just-in-time (JIT)' is among the most debated topics, which will continue to be important at least until 2020, as stated by Piecyk and McKinnon (2009). This Japanese inventory management strategy aims to store only a small amount of inventory to reduce costs and energy used in storage areas (Rodrigue et al., 2001b, McKinnon, 2010, Dey et al., 2011). Keeping higher levels of inventory may be cheaper than having a lower level of stock and replenishing frequently with premium transport (Wu and Dunn, 1995). In consequence, several unsustainable features such as a greater less-than truckload volume and low consolidation have occurred (Wu and Dunn, 1995, Aronsson and Brodin, 2006, Dekker et al., 2012).

Some logistics providers attempt to integrate JIT with GL to maintain logistical efficiency and sustainability. For instance, UPS sends alerts that allow customers to change the date or location of the delivery online; therefore the transportation network is optimized leading to increasing fuel efficiency and reducing miles driven (UPS, 2013, p.37). In addition, a firm's empty trucks are matched with another company's cargo which increases the annual backhaul revenue and fuel savings (Esty and Simmons, 2011).

<u>Reverse Logistics</u>

In the traditional logistics, a certain amount of product is moved forward from manufacturers to end-customers. Whenever there is damage, overstock, salvage and excess inventory, these products are sent back to manufacturers – this is called 'reverse logistics' or RL (Rogers and Tibben-Lembke, 1998, p.3). It interacts with recycling, reusing and remanufacturing activities. Because the remit and visibility of RL practices continue to grow within the GL agenda, operations should fully embrace GL practices to minimize their eco-impact by effectively recapturing value and reducing write-offs (Thiell et al., 2011, DHL, 2013).

2.2.4 Green Supply Chain Management (GSCM)

GSCM involves integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the customers and end-of-life management of the product after its useful life (Srivastava, 2007, pp.54-55). GSCM encompasses several units in the supply chain ranging from first suppliers to end consumers. Hence, an organizational green performance is affected by other units in the supply chain, which, as well as its environmental decisions, can affect other organizations' green performance.

Since logistics activities are located across the whole supply chain, GL is closely linked with GSCM and it sometimes overlaps. This has brought into question: *'Should studying GL adoption focus on a single organization or several organizations in the same supply chain?'* It is necessary to address this issue to structure the thesis.

In observing GL, there are two schools of thought.

Thiell et al. (2011) and the Green Logistics Project (2010) suggested focusing on several organizations, owing to the fact that logistics coordinates many activities (e.g. freight transport and storage) through the supply chain. Because of this, a more sustainable balance between economic, environmental, and social objectives is achievable.

However, focusing on a single organization is found to be more appropriate. Evidence would suggest that many practitioners currently focused on themselves rather than others in the early decades of GL (Choi and Zhang, 2011, Lin and Ho, 2011, Tacken et al., 2011, Chaisurayakarn, 2013). Göçer and Tuna (2013) explained that the increased number of tiers in the supply chain makes it difficult to streamline the sustainability practices throughout the whole chain. Dey et al. (2011, p.1251) take the view that many small GL tasks can be immediately implemented within a company, whereas it takes a dedicated strategy and time to introduce and implement this to other extended parties within the supply network.

This thesis, hence, focuses on an 'internal logistics' or logistical movements inside an organization in order to understand their green practices, as mentioned in section 2.2.3.

2.3 Green Logistics Concepts

Xiu and Chen (2012) claimed that 'Green logistics (GL)' is still a full new concept, which lacks a mature theoretical system, but the social and economic value appears enormous. Therefore, this section presents an overview of the emergence of GL studies, concepts, terminologies, and business response.

(i) <u>The Emergence of Green Logistics</u>

Prior to the 1960s, there was little concern regarding environmental degradation (Murphy et al., 1995). As mentioned, GL is a concept put forward in the mid-80s, at the time that the World Commission on Environment and Development (WCED) initially promoted sustainable development as a goal for international action (Rodrigue et al., 2013) (see Figure 2-2). Public concern and governmental monitoring began to increase, leading to a rising pressure on companies and organisations to take more account of climate change, air pollution, noise, accidents, etc. The pressure become more serious relating to the increasing scale of logistics industries, which is the backbone of national economies (Xiu and Chen, 2012).

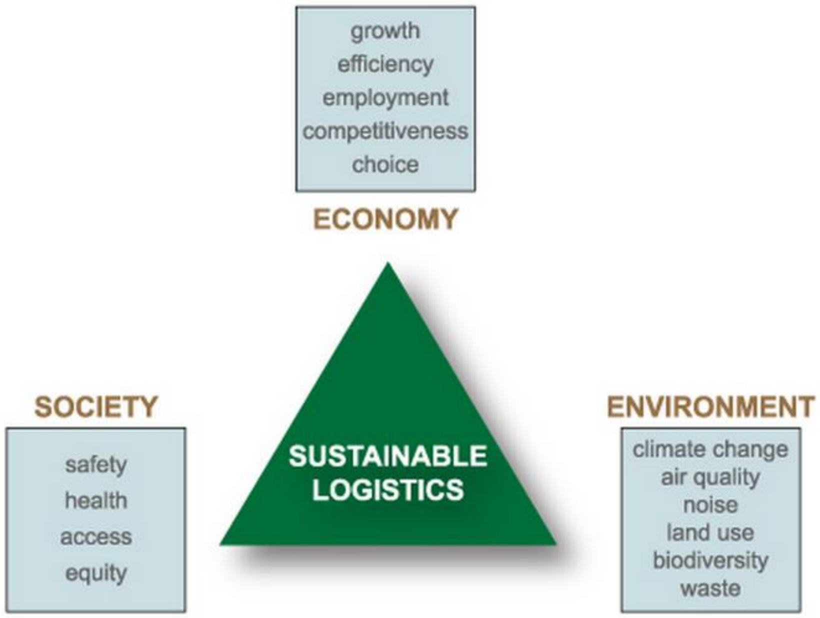


Figure 2-2: The sustainable logistics diagram.
Source: Green Logistics Project (2010).

In the academic world, Poist (1986) seems to have been the first person who raised the key question: *'How do we ensure that logistics and environment will be incorporated into corporate strategy planning?'* This is owing to the fact that the logistics industry is now moving to a neo-logistics era that cannot focus only on logistical competitiveness. Later in 1993, Szymankiewicz surveyed managers whose work involved a logistics function in the UK, concerning their attitudes towards environmental pressure and their responses. This author revealed that legislation is the main factor; which for GL practices include transport control, fuel efficiency, etc. Obviously, the volume of published papers increased at a faster rate after the year 2000 than previously, and doubled or tripled the amount of papers from 2010 to the present (see Appendix 2).

(ii) The Definitions of Green Logistics

Various definitions of GL were found from 15 studies, including: Rogers and Tibben-Lembke (1998), Beamon (1999), Sbihi and Eglese (2007), Ping (2009), Thiell et al. (2011), Lai (2012) et al. and Rodrigue et al. (2013) (see also Appendix 1). Rodrigue et al. (2013) and Beamon (1999) have categorised GL as part of green supply chain management (GSCM), in which GL practices reduce the environmental impacts of logistics activities, and increase cost saving. On the contrary, Thiell et al. (2011) believes that GL is made up of systems that employ advanced technology and equipment to minimize environmental damage during operations, while increasing the utilization of resources within the systems.

In summary, this research defined GL as a system containing both human and physical elements that efficiently manage environmental impacts from logistics functions (through the product life cycle) in order to meet sustainable development goals. This concept was used throughout this research.

(iii) Terminologies of Green Logistics

As mentioned earlier, GL studies have frequently appeared in several disciplines of operations management; accordingly the research boundary of GL is uncertain. For this study, in setting clear research boundaries to gain insight into the principles of GL, a literature review was undertaken using a keyword search ‘green logistics’, seeking to deliver created definitions. Notably, although GL is a commonly used term in academia, there are other names such as ‘environmentally responsible logistics’ (Wu and Dunn, 1995), ‘ecological logistics’ (Rogers and Tibben-Lembke, 1998), ‘environment friendly logistics’ (Aronsson and Brodin, 2006), ‘logistics social responsibility’ (Carter and Jennings, 2002), and ‘sustainable supply chain’ (Srivastava, 2007). This thesis project has adopted the term ‘green logistics’ or ‘GL’.

(iv) How do businesses respond to environmental impacts from logistics?

Göçer and Tuna (2013, p.5) revealed that *“only a few of the logistics companies are following worldwide standards in terms of sustainability both in their company and all through their chain”*. This raises a further question: *‘What are the drivers and barriers to addressing environmental policy in logistics?’*

Various drivers and barriers to GL adoption were identified. They vary by geography as well as by types and size of business.

Drivers

López-Gamero et al. (2010) indicated that if the environmental strategies are driven from green awareness, not legislation, then the outcome of their adoption is significantly positive. Lin and Ho (2011), studying Chinese logistics companies, proposed that organizational support, quality of human resource and regulatory pressure be categorized as the main motivations. Customer pressure seems not to be significant for Chinese exporters, but their perspectives on the environment are very important (Lai et al., 2012).

Non-government motivations are perceived as the main pressures to go green in several areas, such as large Spanish firms (Gonzalez-Benito and Gonzalez-Benito, 2006), the world's leading third-party logistics providers, 3PL (Lieb and Lieb, 2010), and Swedish logistics service providers, LSP (Martinsen and Björklund, 2012).

24 of the 39 CEOs of the world's leading 3PL claimed that the key reason to address the sustainability issue is, 'a corporate desires to do the right thing' (Lieb and Lieb, 2010, p.526). Others, such as customer pressure and increasing image have low importance for them. The driver of Swedish LSPs is their perception, which views themselves to be ahead of the market requirements of green. Lastly, although logistics managers may have a minor role in policy formulation and implementation, their daily decisions have a major impact on environmental performance depending on their awareness (Szymankiewicz, 1993, Murphy et al., 1995, Wu and Dunn, 1995).

Barriers

For small-sized firms, having several constraints (e.g. finance, time, knowledge and human resources), spending high effort on green implementation, which is a long-term process, would interrupt the core operations (Hillary, 2004). Besides, GL benefits are rarely measured, and environmental problems are not viewed as core issues of a business (Murphy et al., 1995). Thus, GL is more likely to be implemented by firms that are larger-sized and in good financial health. Since the logistics function supports multiple activities and related decisions of several firms, internal and external collaborations are a major obstacle to implementing green strategies (Blanco and Cottrill, 2013).

Low eco-awareness is one of the most common barriers found across the nations and in many players (e.g. policy makers, practitioners and customers), leading to problems of low commitment, insufficient support and lack of time (Aronsson and Brodin, 2006, Xuezhong et al., 2011). Kim and Choi (2013) studied lower-ranking staff in five Chinese 3PLs and discovered that personal education background has the highest influence on GL awareness. This knowledge has also driven personal behaviour, attitude and desire; while working position appears not related to awareness level. Currently, it is evident that GL is less commonly considered as a policy instrument. Holt and Ghobadian (2009, pp.944-945) revealed that only 12.5% of British manufacturers have a formal GL policy.

Many firms feel reluctant to go green because improved environmental performance is not always accompanied by increasing economic benefits beyond a certain point (Tatsuo, 2010). Having several such barriers finally generates temporary and passive adoption, or slow progress, in many areas, particularly in low-income nations as well as small-sized business (Hillary, 2004, Thiell et al., 2011, Choi and Zhang, 2011).

Overcoming Barriers to Effective Green Logistics Implementation

A number of solutions were suggested. Ammenberg and Hjelm (2003) recommended implementing joint EMS programmes, in which new practitioners can share costs of hiring environmental mentors and auditors. Murphy et al. (2000) and Lin and Ho (2011) believed that logistics managers were the most appropriate leaders since they best understand the impact of logistics. To reach a sustainable goal, raising eco-awareness by providing education in order to change organizational structure and culture is essential (Aronsson and Brodin, 2006, Göçer and Tuna, 2013). Likewise, this radical change requires the interaction of top-down principles with bottom-up support (Steger, 1996). Choi and Zhang (2011) put forward their views by measuring both tangible and intangible outcomes including awareness, strategies, and financial, environmental and logistical performance.

Still, it is felt that ways to overcome barriers are still insufficient, particularly the problem of low awareness towards environmental issues and protection. Few studies have measured the outcomes of addressing suggested solutions. Raising awareness and related issues will be discussed in depth in section 2.4.

2.4 Green Logistics Implementation Factors

The purpose of this section is to investigate effective implementation factors for GL adoption. Mentioned factors are classified according to key EMS-ISO 14001 processes, including: (i) identifying environmental aspects; (ii) setting goals and policy; (iii) increasing commitment; (iv) education and communication; and (v) monitoring.

However, NYSDEC (2012) stresses that the first step in the EMS building process is gaining top management's commitment, because of providing support and resources. To convince the top, this information regarding the adoption should be given, e.g. benefits, estimated cost, and implementation processes.

(i) Identifying Environmental Aspects and Setting the Goal

To identify key environmental aspects, McIntyre et al. (1998, p.58) have advised undertaking an environmental audit of logistics operations, and listing and priority ranking actions to reduce impacts. Dey et al. (2011) and Metro Vancouver (2009) suggested starting simply in the areas which have low logistics performance with high importance (e.g. transportation), followed by setting the goals. The unsustainable symptoms listed below should be observed (Beamon, 1999):

1. Producing a large amount of waste, hazards, toxins and pollution (air, soil, and water),
2. Using high energy and resources; and,
3. Having low productivity, low average life cycles, inefficient operations, and no economies of scale.

Still, different types of industry will generate different eco-impacts. After that, certain goals can be set. A clear goal helps determine future direction, where limited time-frames or deadlines can provide incentives to take action and move forward (US EPA, 2009, p. 22).

New practitioners can set a single goal (Tacken et al., 2011), such as "to reduce a firm's carbon footprint by 10% a year" (US EPA, 2009, p. 22). Whereas the mature practitioners can have several goals, such as promoting freight consolidation and shifting freight to more fuel-efficient modes (Lieb and Lieb, 2010, p.257). Having an effective environmental policy can change people's behaviour to achieve their goal. The most widely used policy is 'Reduce, Reuse and Recycle' (3Rs) (e.g. Murphy and Poist, 2000).

(ii) Increase Full Commitment

Given that ISO14001 is a human-based system, the implementation of any new initiative or idea would be seriously compromised without full commitment from the entire organization (Daily and Huang, 2001, Edwards, 2004). Top management support and good understanding of their own organization help promote employee engagement to affect changes (Bhushan and MacKenzie, 1992, Daily and Huang, 2001, p. 1,543). The success of the new programme's introduction and change will happen when employees are treated as major stakeholders in organizations, or allowed power in decision making (Daily and Huang, 2001).

This is supported by rewards or incentive programmes, providing training, benchmarking, and increasing communication throughout the organization. Notably, negative attitudes among the top levels and employees appear to be the main barriers (Revell and Blackburn, 2007). Assigning clear roles and responsibilities ensures the system is: (i) achieving the goals and ideals of the organizational policy; (ii) smooth and efficient running; and (iii) directly reporting to the administration (US EPA, 2013). This includes those individuals who are responsible for developing, managing, implementing, and auditing the different components of the system. A well-designed reward system can be helpful in encouraging employees to perform sound environmental practices (Daily and Huang, 2001), and reflecting commitment to the importance of environmental performance (Lent and Wells, 1992). There are several forms of rewards such as awards, profit-sharing programmes, and increase in pay, benefits and incentives.

Addressing GL Practices and Raising Awareness by Education

Open, ongoing and two-way types of communication are encouraged. Implementing open communication, including positive and negative feedback, can build the support of employees (NYSDEC, 2012). Communication can improve environmental performance, raise awareness, generate suggestions for improvement, address concerns and questions and address emergency planning (US EPA, 2012). Information can be delivered by using these channels: training, manuals, meetings, posted bulletins, newsletters and e-mail. However, many organizations have a closed communication climate. To address this problem, the Director has to open his/her mind as well as listen and encourage subordinates to express contrary viewpoints (Stark, 2010). These include comments, ideas, complaints and suggestions, and the Director must respond honestly.

Human resources, particularly their eco-awareness, are the substantial driver for sustainable GL adoption through an organization's structural and cultural changes (Göçer and Tuna, 2013, Kim and Choi, 2013). Currently, raising environmental awareness and addressing GL practices are in the early stages in many countries. The relationships between environmental education, awareness, understanding, attitude and behaviour have not been deeply explored. Sánchez and Lafuente (2010, p.738) revealed their bidirectional relationships as shown in Figure 2-3 below.

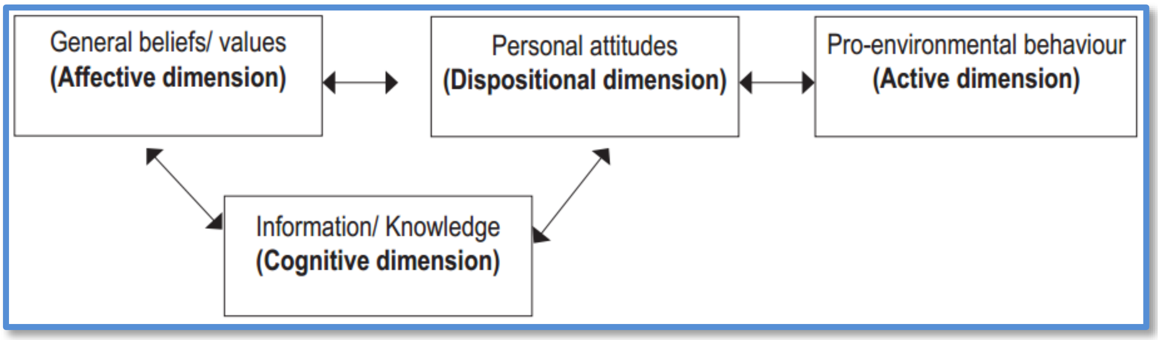


Figure 2-3: Dimensions of environmental consciousness.

Source: Sánchez and Lafuente (2010, p.738).

Figure 2-3 indicates that attitudes increase receptivity to environmental information, while the acquisition of new information can modify attitudes and beliefs. Moreover, behavior can be reinforced or mitigated by certain attitudes; in turn, attitudes can encourage or discourage behaviors. The most valuable outcomes of education, mentioned by Sambasivan and Fei (2008), are improved staff morale and employer-employee relations.

(iii) <u>Monitoring Process</u>

Monitoring determines how well the organisation is achieving its stated environmental goals, by examining various performance (Daily and Su-chun, 2001). This includes on-going environmental recording to trace and protect from damage, as well as periodic audits to determine whether the organization achieves its goals, or required standards. Developing standard indicators provides a valuable database for evaluating environmental performance, and making management decisions (Fraser et al., 2006).

The development of sustainable indicators has to concern both what is important and relevant to track, and what is meaningful to quantify (Clarke-Sather et al., 2011). Chaisurayakarn et al. (2013) generated nine indicators for GL service quality, including containing alternative fuels, vehicle technologies, modal choice and behavioural aspects. Clearly, eco-aspects such as noise, resource consumption apart from fuels, waste reduction, etc. are rarely evaluated. Regarding units of measurement, Logistics Cluster (2013) stressed miles per gallon of fuel used, amount of waste lubrication oil and targets for reducing waste packaging.

Although the wider research area likes the green supply chain, it was claimed by Göçer et al. (2013) that a scale measuring the sustainability within supply chains system is neglected. Choi and Zhang (2011), as GL scholars, can fill some of these research gaps, and below are their indicators:

- *Green awareness,* such as managers having good environmental knowledge, staff having a good GL awareness, and firms paying close attention to green training,

- *Green strategy* such as logistics standardization, integrated distribution, and green technologies,

- *Financial and environmental performance*, such as cost saving, improved brand image, and increased green service satisfaction; and,

- *GL practices*, such as information sharing, packing, warehousing, and transportation, loading and unloading.

Nonetheless, this study did not describe the way to measure levels of eco-awareness and environmental knowledge. Interestingly, firms such as UPS (UPS, 2013)[2] measure cultural changes and customers' satisfaction from green initiatives.

[2] UPS GL measurements: fuels used, emissions, noise, particular matters (PM), accident rates, lead time reduction, idling times, backhaul rates, fleet efficiency, space utilisation, cost reduction, customer satisfaction, alternative fuels used, number of reuse-recycle-remanufacturing, hazardous waste management, awareness, cultural change, mileage, water used, paper used, electricity used, IT applications, legal compliance, green materials, eco-packaging, and sharing resources.

2.5 Green Logistics Practices

From section 2.2.3, logistics contains many sub-functions, including: (i) inventory; (ii) purchasing; (iii) electronic logistics (e-logistics); (iv) transportation; (v) warehousing; (vi) packaging; (vii) office supply; and (viii) waste management and reverse logistics (RL).

This section briefly explains their operations and environmental impacts. Thus, implementing green initiatives from reducing resource use to waste disposal that supports the 'life-cycle' concept is necessary to achieve sustainable development. Because of this, learning an organisation's green practices is the initial research purpose. It supports setting clear research boundaries, as well as being the standard way to identify practice performance (Chapter 4 and 5).

Note: this section also shows that some practices have overlapping areas, such as green warehousing (section v) which has also applied the RL concept (section viii) into its 'hybrid facilities' strategy. Thus practitioners can gain benefits though better green performance.

(i) <u>Inventory Management</u>

There are three types of inventory: raw materials, work-in-process and final products. Inventory management often involves receiving, storing, and movement, physical distribution, and freight transport. Inventory management proposes to achieve a balance between shortage and excess stock within a planning period (Bowersox and Closs, 1996). This brings on-time delivery and minimizes inventory cost. Apart from JIT, which was previously presented, Sugata (2008, p.44) explored the stockpiling in Japanese companies. This author found that the neat arrangement of inventory on shelves instead of piling on the floor reduces the time for pick up. In short, good inventory management is important to avoid shortages and also to reduce waste through loss or over production. In any organisation, the best inventory policy needs a significant amount of analysis and cannot always be pre-determined.

(ii) Purchasing (Procurement)

Many western companies reject suppliers that lack environmental concerns (Murphy and Poist, 2000, p.11), but this is rarely found in developing countries. In China, the decision to buy material from sustainable vendors might bring higher costs and different route planning (Xuezhong et al., 2011, p.335).

Presently, consumers are becoming more ecologically conscious and desirous of purchasing green products (Kumar et al., 2012), hence, business can take this opportunity to better differentiate and position green products within a specific market (PricewaterhouseCoopers, 2010). Green products have been defined as products that conserve energy and/or resources, and reduce or eliminate the use of toxic agents, pollution, and waste (Ottman, 1998). This includes the design of products and services (del Val Segarra-Oña et al., 2011), as well as the changed process to reduce waste and raw materials consumed (Martin et al., 2013). Currently, two key barriers of green products are consumers' lack understanding about green products and product overpricing (Mahenc, 2007, Lim et al., 2013).

Electronic procurement practice, e.g. e-catalogues, e-order fulfillment and e-payment, have been established in many organizations (Rai et al., 2006). As claimed by Piotrowicz and Irani (2010), there are several benefits of e-procurement such as eliminating problems with paper documents, and improved suppliers' searching and order processing.

(iii) Electronic Logistics (E-Logistics)

E-logistics refers to breakthrough technologies such as the internet, GPS, RFID, software, automated distribution centres and databases. It delivers information between suppliers and end users that is timely, accurate, showing availability and internal connectivity (Closs et al., 1997, Rodrigue et al., 2001b). Thus, e-logistics supports both logistics competitiveness and sustainability; for instance, accurate data offers efficient planning results in a reduction of excess inventory (Sarkis et al., 2004, Dey et al., 2011). In contrast, receiving inexact information brings problems related to planning and forecasting, which lead to the need for extra capacity (Pahlén and Börjesson, 2012).

Increasing utilization of e-logistics spawns a number of severe environmental problems (starting from manufacturing of IT products to waste disposal), such as raw materials extraction, chemical contamination, electricity usage and electronic waste (Sarkis et al., 2004, Yoshida, 2010). Areas such as proper recycling and disposing of IT products are receiving little attention, although electronic waste requires a special management process. The situation becomes more serious in developing nations (see Chapter 3, section 3.2).

(iv) <u>Transportation</u>

Transportation is an important logistics activity because, firstly, it connects firms to their customers for delivering customer value (Sanchez-Rodrigues et al., 2010), and secondly, it usually accounts for between one-third and two-thirds of total logistics costs (Ballou, 1998). Accordingly, a greater cost reduction and efficient transport increase competitiveness.

While transport operators want to have regular and predictable demand, the users stress the need to be flexible (Mason and Lalwani, 2007). These different demands are often considered to be inefficient and to increase environmental damage, including pollution, noise, particles or congestion, and fossil fuel depletion (McKinnon, 2010, Pahlén and Carlson, 2013). Many green transport techniques are therefore developed by selecting modes of transport, route planning and scheduling, reducing empty running, consolidation, using green energy, standardisation, sharing vehicles across multiple customers and driver training (Lieb and Lieb, 2010). The study of Göçer and Tuna (2013) revealed one company in Turkey collects waste oil, which is either disposed of or converted to energy. This avoids converting this waste oil into cheap but polluting fuel. Because of this, the project reduces GHG emissions and distance of transport conveying positive economic consequences.

(v) <u>Warehousing</u>

Effective warehouse management maximises the use of space, and minimises movement and the amount of handling (Fawcett et al., 1992). In the past, warehouses supported four main activities, including consolidation, break-bulk, processing/postponement and stockpiling (Bowersox and Closs, 1996). Now, some warehouses have combined recovery centres, called 'hybrid facilities', which also inspect returned products and distribute to manufacturing (Pazhani and Ravindran, 2013). While a 'centralized warehouse' strategy is less energy consuming than several small warehouses (Aronsson and Brodin, 2006), a 'hybrid facilities' strategy reduces both logistical movement and raw materials (Pazhani and Ravindran, 2013).

Several green warehousing practices have been introduced, including eco-design warehouses, solar cells, energy efficient lighting and heating, battery recharging schemes, reusing pallets and containers, and establishing automated warehouse equipment (e.g. picking systems, sorters and palletisers) (Dey et al., 2011, Esty and Simmons, 2011, Thiell et al., 2011, Dekker et al., 2012). Sugata (2008) advises having a neat goods arrangement, such as better product grouping, installing separation boards and indicating a deadline by colour, can reduce waste and make picking the goods easier, for example. The above practices can be applied in both private and public organizations, which will be revisited again in Chapters 3 and 5.

(vi) <u>Green Packaging</u>

Materials such as corrugated cardboard, solid fibreboard, wood, glass, steel, aluminium and expanded polystyrene, are used to produce several types of container, such as trays, bags, boxes, cans, buckets and pallets (Panvalker and Piskolti-Caldwell, 2001, Zhang and Zhao, 2012). Packaging fulfils three functions: protection, preservation and promotion (or information).

Packaging represents 23% of all waste weight (Dekker et al., 2012), hence eco-packaging that can be reused, recycled or degraded should be started up

(Zhang and Zhao, 2012, p.902). The green packaging concept also covers reducing the use of raw materials per unit of product or reducing the weight and thickness of the packaging (Testa and Iraldo, 2010). Green packaging may use variations of inserts, which are simple die-cut cards, to securely hold the fragile portions and eliminate the need for more expensive ‘’fillers” (Donberg, 2003).

The introduction of green packaging can increase expenditure, creating difficulty in embracing environmentally safe packaging (Kassaye and Verma, 1992). Chen and Chai (2010) found that environmental protection did not contribute significantly to consumers’ attitudes on green products. In short, poor consumer’s concern, high price and unavailability hinder practice adoption, particularly in organizations in developing nations (see Chapter 5, section 5.16).

(vii) <u>Green Offices and Supply</u>

Generally, the published papers on GL have not strongly emphasised greening central offices and supplies, probably because the office activities are viewed as not generating high environmental impacts (Esty and Simmons, 2011). Dekker et al. (2012) commented on “green building”, to look at internal transport and emission, the energy use of facilities, and congestion around facilities. New practitioners may adopt a “reduce, reuse, and recycle” lens to spot the opportunities in paper, trash, electricity, water, travel, e-waste and toxic waste (Esty and Simmons, 2011). Birkbeck University (2010) acknowledges that their activities have an impact on the environment, such as energy use, waste and procurement. So, the measures advised include: (i) encouraging staff to share stationery; (ii) using a mug or biodegradable paper cups instead of plastic cups; (iii) avoiding making multiple copies or, preferably, reading documents on computers; and (iv) addressing organisational cultures of open communication. These beneficial measures are recommended for both private and public organisations.

(viii) <u>Waste Management and Reverse Logistics (RL)</u>

Establishing the product life cycle concept needs the controlling of purchasing and inventory in order to minimize waste volumes (McComas, 1995, Morioka et al., 2003). However, obsolete products are unavoidable and commonly found in the warehouse, for which GL seeks alternative uses to minimise storage space and energy consumption required (Thiell et al., 2011, p.341). Some hazardous waste needs proper waste management that increases cost and transportation. Tischer et al. (2013) suggest that well-planned logistics of waste management (such as on-site sorting of waste and recycling, and disposing of waste by logistics service companies) can reduce emissions and increase logistics efficiency by 9%.

Reverse logistics (RL) should not only consider the 3Rs – reduce, reuse and recycle – but should start with redesigning packaging to use less material, or reducing the energy and pollution from logistics activities (Rogers and Tibben-Lembke, 1998, p.2). Consequently, RL requires: (i) investment in developing infrastructure and operations of several processes (like collecting discarded goods, inspecting and sorting them); and (ii) measuring the quality of recovered goods (Dekker et al., 2012). But, the second requirement is difficult, and the cleaning processes may be polluting (Wu and Dunn, 1995, p.31, Srivastava and Srivastava, 2006). Even in the modern green nations (e.g. Norway), effective recycling is highly dependent on a combination of technologically mediated convenience and green consumer-citizenship (a wide range of actors) (JØRgensen, 2013).

Because of the above obstacles, a proper waste recycling programme is hardly ever established, particularly in organizations with insufficient knowledge, resources and staff.

2.6 Key Themes and Patterns of Green Logistics Studies

(i) <u>Introduction to Identifying Research Gaps</u>

Generally, the purpose of conducting a literature review is to identify critical knowledge gaps. This means it should state which study areas are already known and which are unknown, and explain why further study is important to a field (Lillvik, 2011). Before defining this research study area, RMIT University (2005) suggested that the review should:

- Establish a theoretical framework (see e.g. sections 2.2-2.5),
- Define key terms, definitions, and terminology (see section 2.3)
- Identify studies, models, and case studies (see section 2.6)
- Define key research methodology and outcome (see section 2.6)

For the reason explained above, issues such as 'key methodology', the mostly-used methods and design may have a limitation in addressing existing research questions (Robinson et al., 2011). Consequently, the gap is not fulfilled and can contribute to low-quality outcomes, which needs the revision of method selection. In addition, Webster and Watson (2002, pp.15-16) noted that a high-quality review is not confined to one research methodology, one set of journals, one geographic region, or one research field.

Because of these, this section aims to identify studies, key themes/patterns, methodology and outcomes in order to effectively identify the areas that are under-studied.

(ii) <u>Method Used in Identifying Key Themes and Patterns</u>

When searching the word 'Green Logistics' in published papers from Google Scholar, approximately 280,000 results were found. In addition, these keywords were used such as sustainable logistics and environmentally friendly logistics. Only some of those really relate to GL. However, others fit in, such as green supply chain, reverse logistics or even pure logistics that are out of the research focus, and fewer of these really relate to GL adoption, which is this research interest, and is inaccessible. Therefore, only 48 published papers were selected in order to identify key themes and patterns (see Appendix 2).

The selected articles were published during the period 1993 and 2013. 1993 was claimed by Lin (2011) as the year in which GL research was first developed, while 2011-2013 is the period of undertaking literature review for this thesis project. Key authors include Szymankiewicz (1993), Murphy et al. (1994, 1995, 1996), Rodrigue et al. (2001b), Geroliminis and Daganzo (2005), Sbihi and Eglese (2007), Lau (2011), and Lai et al. (2012). Most of the papers were from journals such as the *International Journal of Logistics Management*, *European Journal of Operational Research* and *Supply Chain Management: An International Journal*.

Results of reviewing literature can be summarized as presented in Table 2-1, including research objectives, study region, industry, research method, and research participants. The explanation will be illustrated after the table. Moreover, the full table of 48 studies can be found in Appendix 2.

Table 2-1: Summary of Green Logistics Studies.

Topic	Number	Percentage
1.Research Objectives (one study can have more than one objectives)		
a) Drivers, barriers, organization policy, perspectives, future directions, and impacts	36	35.64%
b) Identify gaps	25	24.75%
c) Identify best practices	20	19.80%
d) Develop model(s)	17	16.83%
e) Develop indicator	3	2.97%
Total	**101**	**100.00%**
2. Region		
a) EU (UK accounts 5 of 16)	16	45.71%
b) China	6	17.14%
c) US/Canada	5	14.29%
d) Japan	4	11.43%
e) Other (South Korea, Thailand, Mexico, Taiwan)	4	11.43%
Total	**35**	**100.00%**

Topic	Number	Percentage
3. Industry (Only Private Sector Found) a) Logistics	10	38.46%
b) Industry related to logistics activities (e.g. manufacturing, retail, chemical, export, pulp & paper, and seafood)	16	61.54%
Total	**26**	**100.00%**
4. Research Method (one study can use more than one method) a) Literature review	24	45.28%
b) Survey questionnaire	15	28.30%
c) Interview and case study	9	16.98%
d) Other (system modelling, algorithms, mathematics analysis, simulation etc.)	5	9.44%
Total	**53**	**100.00%**
5. Research Participants (only interview, questionnaire and focus group methods) a) Managers (mostly logistics managers)	12	52.17%
b) Many levels in organization	3	13.04%
c) Specialists	2	8.70%
d) Did not specify participants	6	26.09%
Total	**23**	**100.00%**

(iii) Research Objectives

The most interesting topics related to GL adoption include drivers, barriers, policy, identifying best GL, outcomes and future trends (see Table 2-1 (Topic 1)).

According to the SD concept, the UN claimed that people are the motor for change, therefore our environmental awareness can be raised by education (UNESCO, 2011). Interestingly, a large body of literature explores the physical elements (e.g. carbon reduction), while very few studies underline human factors in adoption (e.g. eco-awareness, commitment, cultural change) (Choi and Zhang, 2011). Few of these have: (i) observed the relationship between education and awareness; or (ii) developed an indicator for the human element; or (iii) explained the development and usage of those indicators. Additionally, the effectiveness of GL policy is currently poorly understood, since limited GL studies have taken the whole process of addressing EMS into consideration.

Many studies emphasise transportation to explore the possibility to reduce use of fossil fuels and thus carbon emissions. A very limited number of studies have highlighted other pollutants apart from carbon emissions (e.g. waste, toxic waste and resource exploitation), and logistics activities aside from transport (e.g. warehousing, purchasing, and waste management). This trend is quite similar to that identified by Beamon (1999), who expressed this opinion in the last two decades.

Also, these areas require more attention: (i) using an integrated perspective reflecting the combination of three SD dimensions, since GL studies are heavily based on increasing economic and logistics performance (Seuring and Müller, 2008); (ii) developing an information centre that provides practices, according to EMS-ISO14001 steps; and (iii) embracing the concept of life cycle assessment into the research design to reduce environmental impacts at each stage of the product's life and the overall life (Beamon, 1999, Dekker et al., 2012).

(iv) Region: GL Studies in Developed and Developing Nations

As in Table 2-1 (Topic 2), a review of the literature found that GL research is often based on case organizations in high-income nations, including European nations, the United States of America, Canada, Japan, South Korea, Taiwan and China.

The mentioned regions were investigated for these reasons: (i) China is the largest logistics market and economic worldwide (e.g., Choi and Zhang, 2011, Lin and Ho, 2011, Lai et al., 2012); (ii) nations containing companies with superior financial performance and growth mostly implement better sustainability practices (Ameer and Othman, 2012); and (iii) selecting English-speaking countries can avoid various language issues such as translation and back translation (Murphy and Poist, 2000, p.7).

Evidently, the developing nations are nearly absent from GL studies. The World Economic Situation and Prospects (WESP) classifies all countries of the world into three categories based on economic country conditions as below. This classification typically uses gross national income (GNI) per capita, established by the World Bank (UN, 2012b, pp.131-137, World Bank, 2013) (see Appendix 3):

a) Low-income countries ($1,035 or less), such as Afghanistan, Nepal and Ethiopia,
b) Lower middle income countries ($1,036 to $4,085), such as Kenya, Bhutan and Morocco,
c) Upper middle income countries ($4,086 to $12,615) such as Thailand, Malaysia, China, South Africa, and Brazil, and,
d) High-income countries or developed economies (incomes of more than $12,616) such as European countries, United States, Japan and Taiwan.

a), b) and c) are in the group of developing countries. The economic country condition is closely linked with the capability in overcoming environmental challenges. These challenges include limited funds, knowledge and green technology, which slow the adoption process (Thiell et al., 2011). The environmental standards of developing countries are generally lower than the requirement, therefore the environmental effect has been ignored (Wang, 2010). At the global level, the funding mechanisms like the World Bank provide financial and technical assistance to developing countries to tackle climate change (Fujikura and Kawanishi, 2012). In academia, thus, Thiell et al. (2011) stressed the need to explore the impact of developing countries characteristics on the implementation of the GL system.

(v) <u>Organizational Size and Type of Industry</u>

Research frequently deals with large-sized companies in logistics and logistics-dominated industries. Benito and Benito (2006, p.13) gave the reason that “to assure the implementation of the diverse practices considered in the analysis makes sense". GL scholars often study logistics service providers or LSP (38.46%), while the rest (61.54%) comprise of various industries: manufacturing, retail, chemical, export, pulp & paper, and seafood.

For the very specific industries, Montreuil (2011) and Lin (2011) suggested applying an interdisciplinary method to understand their problems and generate a more complete solution. This is because addressing GL often adapts to specific organisational conditions, cultures and geography (Huang, 2009).

Many scholars selected studying a single industry, but focused on various logistics functions. For instance, Ubeda et al. (2011) studied a Spanish food distributor (covering, e.g. delivery, warehousing, e-logistics), in order to know how green practices can meet the efficiency objectives. Some investigated the same logistics functions of different industries, such as Aronsson and Brodin (2006) who examined the distribution system from three case companies (grocery, furniture, and paper) to know how their restructuring impacts on environmental and distribution of products.

Regarding modes of transport, it is likely that there is only one study, Göçer and Tuna (2013) which focuses on several modes of transport: air, road, sea and rail. They highlighted that rail and intermodal transportations are the potential best practices.

Lin (2011) noted that investigating firms in different industrial sectors may reveal dissimilar attitudes towards environmental issues. The study may be challenging when observing SMEs, since they are the major sources of pollution and waste with low levels of knowledge, technology, budget and resources (Ammenberg and Hjelm, 2003, Revell and Blackburn, 2007). Hence, firms are not going far beyond adapting some common practices and are not aware of the importance of sustainability, leading to not taking green issues into their business priority (Göçer and Tuna, 2013).

(vi) Focus on Private Sector or Public Sector?

Table 2-1 (Topic 3) illustrates that private industry was principally selected. Although the green public policy was driven by the public sector, none of the study observes public sector performance (e.g. healthcare, education, and government agency). Such a result is quite similar to the green supply chain management (GSCM), which lacks the environmental supply practices and studies in the public sector (Walker et al., 2008). Instead, most authors paid attention to general environmental management such as Chandrasekar (2011), Farneti and Guthrie (2009), and Walker and Preuss (2008).

Obviously, the impact of studying GL in the public sector would be larger than the private, since it is associated with most of the world population in terms of social development and well-being. In consequence, this area needs more research dedicated to investigation into this discipline.

Note: The public sector primarily aims to distribute the profits to the local communities (Salamon and Anheier, 1997). Also, it is not only ‘mainly financed’ but also controlled by the government, to be part of the government sector (UN, 1993). In many countries, these organizations are mostly controlled by the government, such as hospitals, schools and universities.

(vii) Research Methods

In examining or identifying GL best practices, rich data were mainly obtained from the heads of firms and logistics managers (52.17%) (see Table 2-1 (Topic 5)), as they tend to be the most knowledgeable about environmental issues in the organization (Murphy and Poist, 2000, p.7). Only 13.04% of GL studies in Table 2-1 gained data from all levels in organization. While some studies such as Ho et al. (2009) and Martinsen and Björklund (2012) did not clarify their key respondents (see also Appendix 2). More in-depth and broader information can also be collected from workers who are the most familiar with day-to-day operations and more involved with practice adoption (Ubeda et al., 2011). More reliable and valid data is also obtainable from all rankings, as well as other departments aside from logistics.

The frequently-used approach is a literature review (45.28%) (see Table 2-1 (Topic 4)). It examines the current state of GL practices in order to provide, e.g. recommendations for firms and future research opportunities. The rest are survey questionnaire (28.30%) and case study-interview (16.98%). Since GL adoption copes with both human and physical elements, the literature review and survey-questionnaire can limit in understanding human angles such as attitude and behaviour towards addressing green policy.

Exploration of both physical and human elements can be effectively carried out by using mixed research tools in case study field research (e.g. interviewing, observing behaviours, piloting the study, brainstorming, and group-working of GL experts) (Voss et al., 2002, Piecyk and McKinnon, 2009, Lin, 2011, Ubeda et al., 2011). Mixed method increases the chance of exploring physical and human elements and being able to determine the link between causes and effects (such as 'how environmental education raises environmental awareness.'). Particularly, on-site observation offers better understanding of complex logistical flows (Cherrett et al., 2009).

(viii) <u>Benefits and Paradoxes of Green Logistics Adoption</u>

The key question to be answered in this section is *'Can addressing GL achieve profitability while reducing environmental impacts of the business?'* When integrating an environmental concept into logistics, it appears that many paradoxes have emerged (Rodrigue et al., 2001b). For instance, sharing use of the warehouse can increase transport congestion and warehouse space consumption; and JIT requires more frequent transport that increases use of fuels and carbon emissions. Schaltegger and Synnestvedt (2002) claimed that only specific kinds of environmental approaches can provide better financial performance.

Zhang and Zhao (2012) maintained that the relationship between green management and business performance can have contradicting implications for each, which may come from the different set of variables and/or methodological bias. Firms can achieve sustainability benefits in both the short and long term.

Short-term benefits include minimising waste and air emissions, good customer relationships and cost saving (Aronsson and Brodin, 2006, Lieb and Lieb, 2010, McKinnon, 2010), while long-term benefits include long-term survival and opportunities of operating internationally (Sarkis, 2006). For example, using rail instead of trucks increases carbon reduction and fuel efficiency (Blanco and Cottrill, 2013). But this needs to coordinate with customers and rail services, and making sure that the ordering process is not disrupted. Lastly but most importantly, there is very strong evidence that many nations, such as Japan, Germany, France, Canada and Thailand, have national GL policies and/or guidelines (Geroliminis and Daganzo, 2005, Singkarin, 2012).

(ix) <u>Section Summary, and the Selection of Thailand and the Healthcare Industry</u>

Below is the summary table of research gaps identified (Table 2-2). The GL research gaps at global level principally guided these areas: **developing countries, public sectors, and fieldwork research.**

Table 2-2: Summary of Green Logistics Research Gaps Identified.

No	Research Gap
1.	Holistic view of GL adoption, comprising of all implementation stages
2.	Ways to overcome barriers
3.	Effective indicator, and the test of indicator
4.	Both physical and human elements
5.	Developing nations
6.	Small and medium-sized organization
7.	Public sector, such as healthcare and government agency
8.	Used mixed methods, and fieldwork research
9.	Collect data from all levels in organizations, and related departments
10.	Other logistics functions, apart from transportation
11.	Life cycle assessment
12.	Other pollutants apart from carbon emissions
13.	All sustainable dimensions: environment, social and economic
14.	Adopt interdisciplinary method for investigation
15.	How education can increase eco-awareness/ and adjust attitude and behaviour

The above information brought the selections of Thailand as a case region, and healthcare as a case industry later, purposing to make further contributions. This is because the broad topic will be very difficult to research, thus scoping the research area by geographical area, timeframe, and population group is very necessary (UMFLINT, 2012).

Thailand as Case Region

To select the country for the study, the researcher may explore national policy because it generally guides the research direction to support national development (Singkarin, 2012). Geroliminis and Daganzo (2005) confirm that many nations have GL policy. But in terms of academic research purpose, it cannot be ensured about the GL research needed. This is because each national research policy often mandated by using their own language (Feld, 1998, p.155). There are such as Japanese green logistics of Ministry of Land, Infrastructure, Transport and Tourism of Japan, and Thai Logistics and Supply Chain Research Strategies. Also, mistranslation can occur when the research explores across cultures (Tayep, 2001).

Studying GL in Thailand is chosen for the following reasons:

The first group of reasons: the author is a Thai citizen and sponsored by Thai government, thus: (i) studying Thai regulation can fully understand its requirement; and (ii) it contributes new knowledge to Thailand GL.

The second group of reasons is much more important. It can ensure that the Thai government has encouraged scholars to examine: (i) the possibility to establish GL; and (ii) the development of GL practices/model in several industries. This is according to *the "2nd National Logistics and Supply Chain Research Strategies (2012-2016)"* (pp. 18-20). Its sub-strategy '3.4' encourages exploring GL of 14 key industries[3], including healthcare (NRTC and TRF, 2012a, Singkarin, 2012).

[3] 1. Electrical equipment and electronics, 2. Vehicles, 3. Iron and steel, 4. Petrochemical and plastic, 5. Waste materials, 6. Logistics providers, 7. Pharmaceutical, 8. Wholesale and retail, 9. Hospitals, 10. Textiles and clothing, 11. Crafting, 12. Tourism, 13. Agriculture, and, 14. Mining and ceramics.

"3.4 The Logistics Action Research Concerned with the Generation and Development of the Green Logistics System"

The objectives are:

1. ***To study the ability and readiness of Thailand's industries towards the green logistics management, and,***
2. ***To develop and construct the coordinated cluster within the supply chain towards the green logistics operations"***

Currently, there is one study of Chaisurayakarn et al. (2013) that really relates to GL. This study develops nine indicators to measure GL service quality of Thai logistics providers, such as selecting mode choice and using renewable energy. But this lacks the test of developed indicators, making it less reliable; and it rarely focuses on human elements.

One Thai researcher, Bunlert (2011), expressed an opinion about the future of GL research in Thailand, saying "*currently, there is little research related to green logistics which can be one cause that drives the slow GL adoption by Thai entrepreneurs. Therefore, government should recognize its importance and increase support of this research area, and educate entrepreneurs along with the entire supply chain*".

Healthcare/Hospital as Case Industry

The reasons for selecting healthcare are as follows:

The operations of public healthcare touch people's health at every level of society. The healthcare sector, notably *"hospitals"*, generates a significant amount of hazardous waste (most waste is mixed), and is the key resource consumer (WHO and HCWH, 2009). Many studies found that the effectiveness of waste disposal and control is declining in low-income nations (e.g. Di Bella et al., 2012, Debere et al., 2013, PCD, 2013c). Lack of awareness of appropriate technologies and a weak segregation system bring this problem (UNEP, 2013). Thus, it causes serious health and environmental hazards.

The health sector's global climate footprint is very substantial. For instance, US healthcare accounts for 16% of total carbon emissions, including hospital care, scientific research and the production and distribution of pharmaceutical drugs (Schroeder et al., 2012). The National Health Service (NHS) in England emits 25% of CO_2 each year of total public sector emissions (WHO and HCWH, 2009, p.5). This comprises of procurement (61%), building energy (17%), travel (13%) and commissioning (9%) (NHS, 2013). These figures show that key functions that produce the greatest emissions are involved with 'logistics', of which only highly-related logistics activities account more than 70% (procurement 61% and travel 13%). The above data is the main reason to implement specific environmental practice for them or 'GL', rather than focusing on general practice. This includes the need to understand their logistics activities and its life cycle in order to effectively control/minimize environmental impacts.

2.7 Conclusions

In undertaking a detailed literature review**,** 15 GL definitions were found. The definitions generally outlined the major elements of GL as being logistics, green supply chain, environmental management and sustainable development. A number of GL practices and effective implementation practices have been revealed which included centralized transportation, installing electronic logistics, and raising environmental awareness by education.

A large body of GL literature has been devoted to the empirical study of: (i) drivers of and barriers to adoption; (ii) GL practices; (iii) the evaluation of performance; and (iv) future trends of GL implementation (see Table 2-1 and 2-2, and Appendix 2). The findings also stated that low GL adoption rates were evident, particularly in the following areas: service-based industries, the public sector, developing countries, small and medium-sized firms, lower ranking firms, other logistics activities apart from transportation, and other pollutants apart from air emissions. Also, studying the implementation of GL practices in single organizations rather than across the whole supply chain is more frequent.

A number of GL related areas were under-represented in the literature reviewed and hence possibly under-researched: (i) the whole process of GL adoption, and maturity stages of GL adoption; (ii) product life-cycle analysis to fully control environmental problems; (iii) human elements such as raising eco-awareness, adjusting people's behaviour and corporate cultural change; (iv) performance measurement indicators for both physical and human elements; (v) ways to overcome barriers to adoption; and (vi) designing research by cooperating with the case industry. Since GL adoption is related to several factors, using mixed research methods, and taking fieldwork research offer more in-depth and valid outcomes as mentioned by, for example, Lin (2011) and Ubeda et al. (2011).

In short, it indicates investigating GL adoption in the public sector of developing countries is the key research opportunity. This chapter narrows down to present the rationale for selecting public hospitals and Thailand, as case organizations and case region respectively. **Because of this, studying GL adoption in Thai public hospitals is the initial aim of this research, an in-depth exploration of which will be presented in Chapter 3.**

Chapter 3: Reviews of Green Logistics in Thailand Healthcare

From Chapter 2, the GL research was reviewed in general identified that not much research had been done in any of the following areas: developing economies, public sector, and healthcare. Later, it points to study GL in Thai hospitals which covers all three under-researched areas.

This chapter provides a brief overview of Thailand, characteristics of healthcare administration, and current issues regarding green logistics (GL). After that, the most important areas to be investigated are presented to determine their contribution to new knowledge. Since both logistics and environmental management in Thai healthcare is very limited, conducting (i) a review of GL practices in Thai hospitals and (ii) a review of international practices are very necessary.

3.1 Introduction to Thailand's Healthcare and Logistics

This section investigates the characteristics of Thailand as a developing country, and its public hospitals, which is the research case industry/setting. In detail, it observes the hospital types and sizes, administrative structure, policy compliance, logistics and supply chain, and green practices. Key areas of focus for this study, as informed by the extant literature, are further examined below.

(i) <u>Research Focus in Thai Public Healthcare</u>

Yousapronpaiboon and Johnson (2013) revealed that Thailand's private hospitals generally deliver better quality of services than public hospitals in many aspects including knowledge, experience, timeliness, up-to-date equipment and hospital environment. Thus, exploring Thailand's healthcare or 'public hospitals' was suggested by Singkarin (2012, p.69), who headed the development of the above mentioned national research strategies. Singkarin (2012) suggested that Thai scholars should investigate three main topics as follows.

- Study ‘Green Hospitals’, in order to reduce environmental impacts of the whole supply chain, to reduce CO_2, to realize the ability of investing in the green supply chain, and to increase value in the supply chain,

- Study the development of logistics management in district hospitals, and,

- Study the integration of patient data and other resources (database development), which supports the efficient exchange of data between hospitals.

From Singkarin’s suggestion, this research focuses on only green hospital and logistics management. Subsequently, the details of key study areas and the selection of case hospitals will be presented.

(ii) Thailand in Brief

Thailand is the only country in South East Asia to have escaped colonial rule (BBC News, 2013). It is a middle-income country with an area of 514,000 square kilometers (Auamkul et al., 2003) (see Figure 3-1). The country is divided into 77 provinces and 878 districts, as well as six geographical regions: central (including, Bangkok – the capital city), northern, northeastern, western, eastern and southern. Thailand’s population is 68 million, of which the Northeastern region has the largest proportion (28.7%) (NSO, 2010).

Nearly half of adults are employed in agriculture. Currently, about 35% of the population live in urban areas, and this is expected to increase to 40% in 2020 (WHO, 2011). More than 90% of Thais are self-defined as Buddhist. Thailand has suffered from a high turnover rate of government, and has experienced several rounds of political turmoil, including a military coup and large-scale street protests (CIA, 2013). For example, the Bangkok shutdown has led to a logistics bottleneck. Future environmental challenges include climate change, increasing urbanization, air and water pollution, and the dangers of hazardous waste and chemicals (WHO, 2011).

Figure 3-1: A map of Thailand.
Source: Google Map (2013).

(iii) <u>Type and Size of Public Hospitals</u>

In Thailand, 93 % of hospitals are public, located across the country, controlled by the Ministry of Public Health (MOPH) (Valdmanis et al., 2004, NHSO, 2013). The MOPH centrally decides matters such as the amounts of budget allocated, labour employed, organizational structure, and communication method (paper-based). According to the National Health Security Office (NHSO, 2013, p.57), there are 834 hospitals as follows:

- 13 University hospitals (160-2,221 beds),
- 26 Central hospitals (more than 500 beds),
- 74 City hospitals (or general hospitals) (120-500 beds), and,
- 721 District hospitals (10-120 beds); divided into small-size (30 beds or fewer), medium-size (30-90 beds) and large-size (90-120 beds).

In the NHSO report, 47.46 per cent of outpatient care was accounted for by the primary care unit (PCU); followed by district hospitals (34.99%) and city/central hospitals (13.53%) (NHSO, 2013, pp. 63-66). For inpatient volume, the district hospitals accounted for the greatest amount of 48.01%, followed by city/central hospitals, 40.05%.

(iv) Administrative Structure and Hospital Accreditation (HA)

All types of public hospital are governed by the hospital director. The smallest hospital (district type) must contain 11 departments (Ministry of Public Health, 2013a). They are administration, medical technology, dental care, pharmacy, medicine, nutrition, radiology, rehabilitation medicine, health insurance, family medicine, nursing (including OPD, IPD, ICU, delivery room, central sterilisation unit, surgery and anesthesia, emergency). The administration of larger hospitals is more complex, because of offering wider ranges of both general and specialist services. For instance, city and central hospitals have service centres, such as paediatrics and surgery, which are not provided by district hospitals.

All public hospitals are encouraged to receive a hospital accreditation (HA). This system provides structure and process for ensuring continuous improvement in the quality of healthcare and appropriate development (WHO, 2003). The indicators are such as improved quality of the pharmaceutical system, better medical records systems, and complaint management.

It is found that these HA criteria are related to and support GL implementation. HA has three levels: first accreditation, first round re-accreditation, and second round re-accreditation. In 2013, 42.65% of public hospitals had received HA, while 51.78% had been re-accredited for the first time (NHSO, 2013). For ‘good performance’ hospitals, re-accreditation takes place every two years. The key incentive adopted is linking HA performance with allocated budget (NHSO, 2011). Therefore, all requirements mandated by HA have become compulsory activities.

(v) Supply Chain and Logistics in Thai Healthcare

The pharmaceutical supply chain has been explored since 1999, looking at factors such as barcode systems, purchasing, and quality of cold storage drug transportation (WHO, 2003, Sooksriwong, 2009). But, the problem of low/no data exchange within public hospitals and with suppliers remains (Singkarin, 2008, Sooksriwong, 2009, Kritchanchai and Muangchoo, 2013). Thus, it limits tracing data, and poor information systems increase medical resource shortage. This issue was firstly addressed in 2012-2013 by these research projects: (i) testing supply chain management in Siriraj Medical School (Vanichchinchai, 2012); (ii) developing a 'National Drug Code' system; and (iii) establishing an effective blood supply chain and information system (NRTC and TRF, 2012b).

However, private hospitals have already implemented integrated supply chains and e-logistics. For instance, Bangkok Hospital has adopted e-logistics to manipulate all requests (e.g., blood, medicine, medical supplies, and information) from its 17 branch hospitals, and uses a barcode system for tracking and tracing patients and products (Transport Journal, 2012). These e-logistics practices are also applicable there: e-catalogue, automatic laboratories, AVL (Approved Vendors List), and PDA (Personal Digital Assistant) (in the ward).

Wongtabtim (2012) found that reporting lab test results in an electronic form can save more than 1.3 million Baht, due to the reduction of redundant lab tests, and paper use. A medical stock controller should have knowledge regarding medicine, accounting and finance and supply chain management in order to successfully solve stock shortage (Limwong, no date).

Singkarin et al. (2008) indicated that both physician decision making and too many discharge processes can limit the number of patients admitted to the ward. To address this problem, it has been suggested that a tablet PC be used for discharge orders, and arranging another place for discharged patients. However, many public hospitals are regularly overflowing with patients, with bed shortages leading to patients receiving care in corridors, other wards, or nearby hospitals (Ariyasriwattana, 2008). Thus, the idea of providing such a reservation area could hardly be adopted.

Singkarin (2009, no page) took the view that "*Public hospitals have low e-logistics performance, which needs other subsystems like real time inventory movement, reconciliation, data synchronisation, drug replenishment (DSS), sharing of inventory information with vendors; reducing the procurement approval process, and e-transactions."* Singkarin (ibid) claimed that the just-in-time (JIT) concept can upgrade the flows of service, information, and medical inventories, resulting in improved treatment standards and safety. Sameer et al. (2008) argued that JIT brings higher risk of inventory and medical supply shortages for countries in which the healthcare supply chain is not well connected and consists of a paper-based system.

(vi) Environmental Policies Implementation and Issues

The MOPH declared its intention to strive to meet the WHO's global warming policy in 2009 (Punpeng, 2011). It is particularly concerned with increasing awareness, knowledge and understanding of public health personnel, and developing a good practice model for hospitals to cope with global warming.

GREEN and CLEAN Policy

The MOPH, through the Department of Health (DOH, 2012), has promoted the "*GREEN and CLEAN*" campaign (see Table 3-1). It is supported by elements such as the SEP concept, existing hospital energy-saving programmes, and current community-hospital networks (Punpeng, 2011). GREEN relates to environmental activities: which stands for garbage (solid waste), restroom, energy, environment (healthy workplace) and nutrition. CLEAN is an implementation strategy and stands for communication, leadership, effectiveness, activities, and networking. In addition to this, knowledge, training, carbon footprint indicators, and the list of learning centres are provided.

In 2010, the DOH awarded 13 best GREEN and CLEAN hospitals. For example, Phichit Hospital has cooperated with the organic farming network to provide sufficient food materials to the kitchen. Petchaboon Hospital aimed to reduce energy cost by 20% within two years. The key measure is raising awareness, while others include, for example, using pull-switch lighting, installing solar cells, and walking upstairs instead of using the elevator. These can reduce about 300 tons CO_2/year, and 10.33 % of energy cost a year (or 200,000 Baht a month).

Table 3-1: GREEN Activities (as per the GREEN and CLEAN campaign).

GREEN	Concept and Practice
G: Garbage	*Concept:* using the 3Rs principle or reduce, reuse and recycle
	Practice: establish recycling banks (or recycling centres) and sell recyclable waste, reuse paper and packaging, reuse steam water, use waste to produce effective microorganism (EM) and organic fertilizer, feed earthworm to decompose waste, donate waste, minimize the size of packaging, use paper bags, and use multiple-use containers (such as dishware, mugs, bottles)
R: Restroom	*Concept:* restrooms management should meet HAS (Health Safety and Accessibility Standard)
	Practice: replace chemical cleaners and disinfectants with biological ones, and, replace chemical fertilizers with waste water from toilet and sewage system
E: Energy	*Concept:* energy saving and using alternative energy such as wind, sunlight and biogas
	Practice: turn-off electric equipment when not in use, set opening and closing time of air conditioning, replace fossil fuels with own-produced biogas and LPG, encourage walking, cycling and carpool
E: Environment	*Concept:* environment management to reduce global warming and promote a healthy environment that focuses on landscape, architecture, healthy workplace

GREEN	Concept and Practice
	<u>Practice</u>: increase the green areas, increase ventilation and sunlight, have 5S (cleaning up, organizing, cleaning, standardizing, and training and disciplines), and, address healthy workplace project
N: Nutrition	*<u>Concept</u>:* focus on food safety, free from chemicals, local vegetable/food
	<u>Practice</u>: purchase or grow organic and local food materials, have local menus, use less meat, and arrange green market

Sources: Punpeng (2011) and Department of Health (2012).

<u>Issues from the GREEN and CLEAN Policy</u>

From reviewing the GREEN and CLEAN policies and practices of the Department of Health, many **weaknesses** were found:

(i) It presents only the successful practice and their outcomes, but there are very few step-by-step tips for practice adoption.
(ii) There is no strong indicator to identify the best practice performance, such as no indicator for measuring the volumes and quality of biogas and EM produced.
(iii) There is no clear criterion in selecting the best hospital. (And when visiting case hospitals, Hospital “C” and “D” also did not know clearly why they were selected to be best practice hospital).
(iv) For each practice, there is no clear amount of money invested, and returned, as well as no clear environmental benefits.
(v) No limitations or cautions provided when addressing the suggested practices.
(vi) None of the evidence informs the contradiction between GREEN and CLEAN policy, and the general policy/regulation.

In summary, there is no evidence yet that these are best policies. The point is that GREEN and CLEAN is not evidence-based and appears to be applied inconsistently. Therefore there is a need for research to identify key areas of development for GL in Thai hospitals, to identify best practice in those areas and to include best practice to promote and implement GL best practice.

General Issues when Addressing Environmental Policy

Many scholars agreed that the hospital Director is the most important factor for the adoption of new practices. Panyaping and Okwumabua (2006, p.89) stated that, "*Without support from the hospital directors, good government regulations and better environmental awareness of the staff, introduction of waste management programmes will be difficult"*.

Another example is that if the Director addresses green programming because of the need to pass the annual evaluation, and to increase the hospital's positive image, this would be a great hindrance to success (Sanguanchom, 2010). Jongwutiwes and Thiengkamol (2012, p.303) revealed that paying attention to worker behaviour in their everyday practising is the most important factor for hospital environmental management, and it is the most rapid and cheapest approach. Environmental education is an important change agent to shape sustainable behaviour in everyday living leading to successful management (Gonggool et al., 2012, Morrasri et al., 2012).

(vii) Sufficiency Economy Philosophy

As a branch of 'Sustainable Sufficiency', the SEP was developed by King Bhumibol Adulyadej, a head of the Thai monarchy, in the 1950s based on Thai culture and Buddhist principles (Chaipattana Foundation, 2012). The first focus was on self-reliant or sustainable farming.

Since Thailand encountered a rapidly changing environment (economic crisis) that significantly affected the country, the SEP has been principally adopted in guiding the Ninth to Eleventh National Economic and Social Development Plan

(2002-2016) (NESDB, 2012b). The vision of this national plan is *"A happy society with equity, fairness and resilience"*.

SEP takes the view that modern development and the rise of consumerism has led to a deterioration of natural resources. Thus, the development is based on moderation (Buddhist middle pathway), reasonableness, and risk management; which uses knowledge and virtue to solve problems and give guidance in living (Khamman, 2012, Chaipattana Foundation, 2012) (see Figure 3-2).

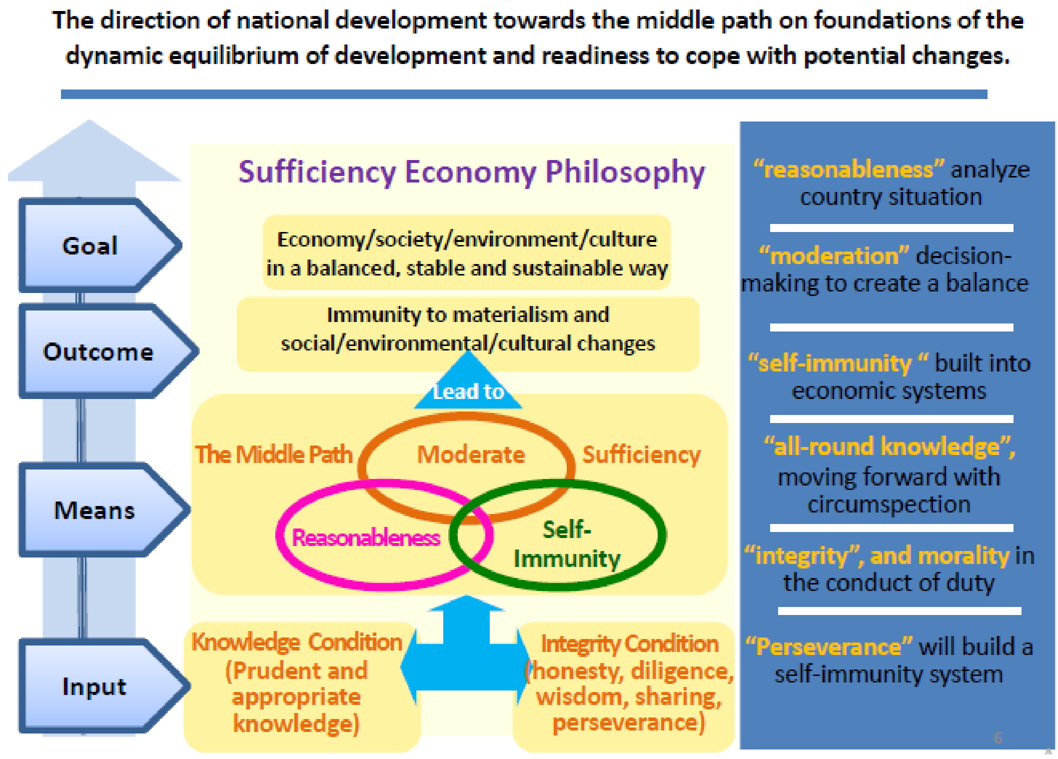


Figure 3-2: A structure of the sufficiency economy concept.
Source: Khamman (2012).

As a result, natural resources are reserved and stored; consumption patterns have been adjusted towards being environmentally-friendly, lifelong learning is being promoted, and strong community networking is addressed.

SEP can be applied within families, communities, organizations, and a nationwide scope. The guidelines of SEP are such things as 'economize by cutting down expense in all aspects', and 'leading one's life by following the good path and adhering to religious principles (e.g. mercy and harmony)'. SEP practices include: (i) producing, consuming and exchanging local products; (ii) producing effective microorganisms and organic fertilizer; and (iii) integrated farming – “Grow everything we eat, and eat everything we grow”.

In short, after the economies of families and communities are firmly established, progress can be continually promoted to prevent incurring failures (Chaipattana Foundation, 2012). Because of this, SEP is the economy that is knowledge-based, ethical, happiness-creating, and sustainable.

(viii) <u>Applying Sustainable Sufficiency Economy in Green Logistics and Healthcare</u>

Existing literature indicates that the sustainable sufficiency (SS) concept can be applied to all sectors at all levels (e.g. UNESCO, 2013, Chaipattana Foundation, 2012). There is a question regarding the feasibility and application of how SS as a concept can be integrated within a business sector that has a profit-oriented mindset.

Many authors suggested tackling *‘over-promotion’* strategies to mitigate *‘over-consumption’*, as these are key causes of unsustainability (e.g. Young and Tilley, 2006, Jackson, 2009, Bocken et al., 2014). Bocken and Short (2015) suggested curbing demand through education and consumer engagement, making products that last longer and avoiding built-in obsolescence, focusing on satisfying ‘needs’ rather than promoting ‘wants’ and fast-fashion, conscious sales and marketing techniques, new revenue models, or innovative technology solutions. Hence, the problem is solved at a strategic level, and is more focused on human aspects (e.g. awareness, attitude and behavior), which offers a more sustainable outcome.

Focusing on the logistics industry where this research fits in, some ‘sufficiency solutions’ have been identified such as adopting sustainable production, extending product life, reusing resources, sharing use of resources, and using renewable energy (e.g. Boons et al., 2013, Bretzke and Barkawi, 2013). These are also viewed as increasing logistics efficiency practices and GL technology. At the international level, Bretzke and Barkawi (2013, pp.443-445) wonder if it is possible to come close to carbon-free transportation (although firms have adopted the above practices), since there are several barriers to this, particularly international politics and economic crises.

It is likely that this mainstream economic view strongly attacks for-profit organizations, rather than the public sector which is mostly funded by the government. SEP, as a branch of the SS concept, also provides guidance for public sector operations to bolster success in following this principle. For example, it suggests that all nations should, “Implement mega projects with reasonableness and concern on risk management. The budget allocation is designed with the focus on balanced investment” (UNESCO, 2013). Below are the example SEP’s practices on the public healthcare industry (Hongsranagon, 2009):

1. *Moderation*, ‘the relationship between physician and patient should be a human not a commercial one’
2. *Reasonableness*, ‘overuse of drugs at the request of patients should be replaced by rational drug use stated by the World Health Organization (WHO)’, and ‘appropriate use of available resource’,
3. *Self-Immunity*, ‘health promotion behaviour’, and,
4. *Knowledge*, ‘research-linked policy decisions to gain successful results and suitable use of resources’.

SEP can be utilized as an overarching mindset in addressing the five-steps of the environmental management system (from policy development to management review). For instance, its philosophy on using local resource wisely should ground the idea of increasing use of Thai herbal medicines, which could cut down on imported items. Another example is sharing knowledge, where the hospitals can share good green practice (e.g. waste segregation) with the community. This can support the SEP goal, or sustainable society, in the long term. From a wider perspective, the MOPH should create policy/regulations based on SEP, such as the economical use of resources (e.g. sharing use of paper documents in the meeting to reduce paper usage).

3.2 Key Issues of Thailand's Public Hospitals

Although the above sections have focused directly on Thailand public hospitals, this as a defined research scope is still too broad. This is due to the healthcare context being complicated and sophisticated, in that it comprises various resources, waste, and logistics functions, bringing difficulty in addressing green initiatives. In a bid to reduce the focus of this study whilst maintaining the integrity of this work, this has led to asking the following question:

> *"What are the key environmental aspects of the hospital, and their environmental practices?"*

In order to understand key hospital issues, various sources of information were reviewed, such as published papers, government policies, and hospital reports. The selected sources were mostly published after the year 2000, in order to reflect the current situation and to be able to identify the areas to be studied. The researcher searched using keywords such as 'current Thai hospital problems' and 'crisis in Thai hospital'. Then, the information was grouped into their topics such as waste management, medicine, and finance.

(i) Urgent Waste Management Problems

When looking at key environmental impacts, waste management is among the most debated issues of Thailand healthcare. Proper hospital waste management is certainly necessary, as hospital waste generally contains toxic chemicals and pathogens that are seriously hazardous to human health and the environment (Manyele, 2004, WHO, 2011).

Evidence reviewed shows the following problems exist within Thai hospitals: (i) no standard of IW disposal; (ii) the mixing of infectious waste and general waste (GW) in transportation and burning; (iii) leakage; and (iv) the low quality of the hospital's incinerator that produces a high effluvial smell and smoke (e.g. Ozaki et al., 2003, Khunprasert et al., 2007, Kanchanabul, 2008, Ali and Kuroiwa, 2009, Sirikhun and Pitaksanurat, 2012, PCD, 2013c). For instance, discarded films and the spent solutions that comprise hazardous waste are commonly discharged into the environment without any proper treatment (Khunprasert et al., 2007).

Manowan (2009) claimed the factors resulting in poor waste management are type of hospital and insufficient knowledge. Others pointed at insufficiencies of monitoring by the Director, budget and protections. These problems are recurring, even if it has been controlled by, for example, the Infection Control Regulation (year 2003) and the Hospital Accreditation (HA).

142 hospitals have their own infectious waste (IW) incinerators, but they are mostly worn out. That is why third party services are mostly used (PCD, 2013b, PCD, 2013c). Currently, Thailand has only 14 IW handlers, of which 10 are local municipalities, and four are private companies. These 14 handlers have to manage 35,000 tons of IW or 70% of total IW. It is evident that IW is sometimes disposed into the public facilities because the hospital incinerators are not functioning. The Pollution Control Department (PCD) makes several suggestions, for example, establishing a recycling community, returning salvage of product, developing research and technology, and transforming waste.

However, it is difficult for the above suggestions to be put into practice as the following evidences. The Department of Health (DOH) (Roongruethaiwat, 2013) and PCD (2013b) reveal that about 90% of local municipalities have received insufficient budget to construct IW incineration. The municipality itself also mentioned problems like no strong IW handling guidelines, evaluation systems, or lists of waste handlers (Roongruethaiwat, 2013). This shows the urgency of developing good IW management systems.

(ii) Overuse of Medicines and Medical Supplies

Whilst a hospital uses many resources, medical supplies are the most important ones in terms of their absorption in medical treatment, their cost (more than 60% of total material costs), and the increasing upward trend of use (Lapsuwansakul and Kunkum, 2012). Jongudomsuk et al. (2012) revealed that the use of non-essential pharmaceutical items accounted for 67% in 2010 or 41% of total prescriptions among 34 case hospitals. The authors claim that this is another result of the 30-Baht scheme that increases outpatient attendance and expenditure.

Thailand has to import high-technology medical supplies (e.g. x-ray equipment and orthopedics devices) (NESDB, 2012a). Wanichsun (2012) has uncovered the following problems within Thai hospitals: over-ordering lab tests, redundant medical procedures or prescribing of medicines, and no standard guidelines. Chaiyakunapruk et al. (2012) found the prevalence of oversupply due to medications for chronic diseases. It ranged from 23.2% to 62.8%; total amount of loss was US $32,903 or 3.77% of total medication costs. Overusing antibiotics is also endemic, caused by prescribers' poor understanding of antibiotics and their role in disease management, and patients' requests for antibiotics (Sumpradit et al., 2012). This overuse leads to increased antimicrobial resistance posing a threat to human health and welfare, and leading to financial loss.

(iii) Reduction of the Cost of Medicines and Medical Supplies

In 2012 the MOPH introduced the policy, "Reduce cost of medicine and medical supply by 10%" (Ministry of Public Health, 2013b). This is supported by such goals as: (i) establishing joint procurement by hospitals within the same region to increase purchasing negotiation; and (ii) implementing the standard cost accounting system to effectively record and monitor cost. To increase efficiency of medicine stock management, the MOPH (2012) has set several policies:

Improve rational use of medicine,

- Have hospital committees for monitoring product selection, procurement, distribution and use of supply,
- Set the maximum amount of medicine items for the medical school (750 items), central hospital (700 items), city hospital (550 items), and district hospital (375 items),
- Have only one item for each generic name,

- Increasing use of an Essential National Medicine National List for central hospitals (> 60%), city hospitals (70%) and district hospitals (80%),

- Reduce stock reservation (turnover rate) to be less than 3 months,

- District hospitals have to distribute medicine to their controlled primary care unit(s) (PCU),

- Select uses ‘unit dose’ or ‘daily dose’ systems, and monitor returned medicine from the ward, and,

- Increase monitoring on ‘Automatic Stop Order’ drug, particularly ‘Antibiotic’ with the campaign ‘Antibiotics Smart Use (ASU)’.

(iv) <u>Hospital Financial Crisis from 30-Baht Scheme</u>

In 2002, a 30-Baht Universal Coverage scheme (UC) (or £0.60 per visit) was formally introduced into 640 public hospitals (Ngorsuraches and Attapon, 2006). The budget is controlled and distributed by the National Health Security Office (NHSO). Theoretically, the UC increases access to healthcare services, particularly for rural and poor people encompassing approximately 70 percent of the population (Ngorsuraches and Attapon, 2006, NHSO, 2013).

The UC has generated hospital financial losses since these hospitals never had limited budgets before (annual capital budget of 2,921.66 Baht per head). The public hospitals receive only 60% of the total budget. In addition the NHSO has often distributed the budget late and is accused of conflict of interest (Ariyasriwattana, 2012). These factors have brought several problems. Experienced medical staff have moved to private hospitals, because of factors such as an imbalance between workload and earnings, and a lack of budget to purchase new medical tools, equipment or good-quality pharmaceuticals.

As a result, public hospitals have experienced a specialist shortage, particularly in district hospitals in rural areas (Hughes et al., 2010). Instead, they operate with new physicians with little experience, who are responsible for a large volume of patients. This can lead to issues such as increased errors during treatment, and medical resource overuse (e.g. over-ordering lab tests) (Ariyasriwattana, 2012, McManus, 2012).

Some hospitals withdrew from the UC after facing losses (Manager Online, 2006, Thai Hospital Organization, 2010). For instance, Thammasart University Hospital, which provides high quality medical care services, which had a loss of more than 100 million Baht, decided to withdraw in 2006. Srirattanabun (2007) discusses the future directions of UC that requires a better budget allocation system, a better healthcare integration system and promoting self-care. Despite the above suggestions were given since 2007, all problems remain as the above evidences. Interestingly, Thailand's national policy is to become a medical hub of Asia, while the current issues related to basic health services are unsolved.

(v) Initial Research Gaps

Most studies, such as Singkarin (2008) and Vanichchinchai (2012), have explored large-sized hospitals in Thailand to develop effective supply chains and/or logistical models. In doing so, they often selectively investigated part(s) of whole hospital operations, such as pharmacy, laboratory and wards. In sections 3.1-3.2, we have found several understudied areas that affect GL implementation:

- The combination of logistics and environmental management or GL,
- Improved hospital logistics performance involving resource and waste (all categories), patients, information, and finance flow. This is because these flows often move simultaneously,
- The development and establishment of e-logistics, and, the MOPH policy compliance and results.

In keeping with the authors Dey et al. (2011), who review GL adoption in developing nations, the authors deem it appropriate to explore the environmental performance of internal logistics rather than the supply chain (see Figure 3-3). Key reasons are as follows.

Firstly, healthcare/hospital supply chains are complex and not always within the control of a hospital management team. Next, both logistics and environmental management are not currently well-addressed in the early decades of GL adoption. Lastly, Thai public hospitals still have poor coordination within the supply chain as previously mentioned. Therefore the choice to explore GL in a single hospital is pragmatic in terms of realistic impact and what can be achieved in one PhD study.

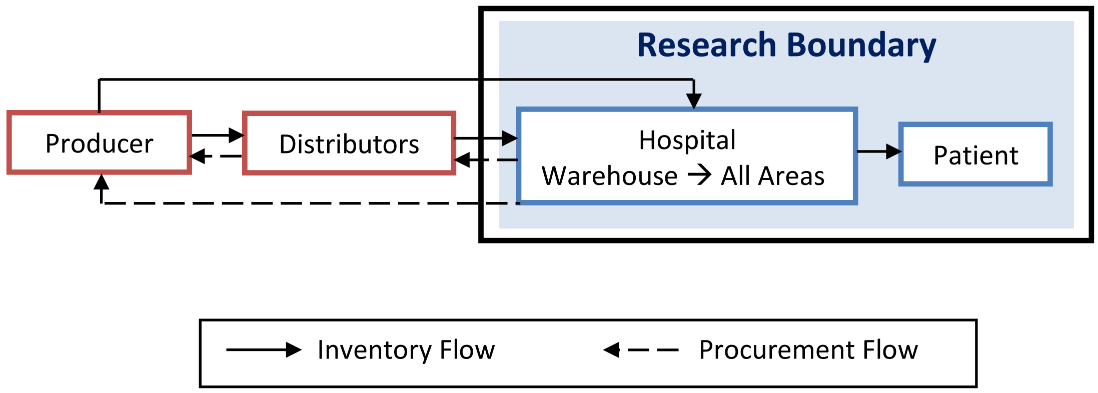


Figure 3-3. The research boundary of hospital green logistics.
Source: Modified from Smith et al. (2011, p.51).

3.3 A Preliminary Review of Current Practice in Thai Hospitals to Confirm Findings from the Literature Review and to Guide the Research Focus

ESC (2003) and NHS (NHS, 2013) state that to effectively reduce resource use and waste requires a deep understanding of each product's life cycle. This means: (i) how resources enter and move through a hospital; (ii) how used resources (waste) are managed effectively; as well as (iii) who has interacted with these resources and waste. However, this knowledge is limited in Thai public hospitals as mentioned. In order to inform the research focus and next steps for this study, a preliminary review of current practice within Thai Hospitals (or THP Preliminary Study) was undertaken. This is in the 4th step shown in Thesis Diagram (Figure 1-1).

(i) <u>Designing an Interview Approach and Analysis</u>

As a precursor to the main empirical data collection (as explored in the following chapters) Thai hospital personnel were interviewed to capture data which reflected the real phenomenon/current status quo. The aim of this subset of activity was to get an actual interpretation of GL implementation as opposed to that as reported in the scant literature base.

There are four main requests and questions that were used in the interview process:

1. Please explain your hospital environmental programme.
2. What are the main flows of hospital logistics?
3. What are the main categories of resource and waste?
4. How do these flows move inside the hospitals?

Interviews with nine personnel took place: including; three physicians (one of them is the hospital director), one pharmacist, one occupational therapist, one nurse, two medical technologists, and one public health officer (see Table 3-2).

Semi-structured interviews were considered most appropriate in accessing situational-based information whilst allowing some flexibility with the line of questioning (Robson, 2013). For confidentiality reasons, all names and workplaces were anonymized.

Table 3-2: List of Interviewees.

Hospital	Type of hospital	Position
Hospital #1	Central Hospital	1. Occupational Therapist 2. Public Health Officer 3. Nurse (Paediatric Ward)
Hospital #2	City Hospital	4. Pharmacist
Hospital #3	District Hospital	5. Hospital Director (Physician)
Hospital #4	University Hospital	6. Medical Student (Studying Internal Medicine)
Hospital #5	District Hospital	7. Physician
Hospital #6	District Hospital	8. Medical Technologist
Hospital #7	District Hospital	9. Medical Technologist

Interviewees were from four types of public hospital: university hospital, central hospital, city hospital, and district hospital. The interview processes took approximately 30 to 60 minutes.

Firstly, the interview data were transcribed. Then, these answers of interviewees were highlighted for the main idea and taken note of, which was later supported by grouping them according to above four main questions, so that this process mainly uses a simplified content analysis method to specify characteristics of a message (Stemler, 2001). When reviewing the interview transcripts, the similarities and differences of the answers were noticed whether because of such factors as working in different hospitals or professions. Thus, cross-case analysis was employed to gain deep understanding of similarities and differences across cases (Miles and Huberman, 1994, p.173). A case in this preliminary study refers to one interviewee.

(ii) The Preliminary Review Outcomes

The results of the preliminary review (nine respondents) produced the following insights:

Hospital Environmental Programme

Interviewees had heard about GREEN and CLEAN programmes, but their hospitals (by the Director) have not yet registered with the Department of Health (DOH). This is because it is optional. Hospital Accreditation (HA), by which performance relates closely to budget allocation, is perceived as the main driver to address the formal environmental policies. They are such as waste segregation, reducing the use of air conditioning, reusing paper and increasing green areas, which are standard criterion for awarding HA. Though, some reported progress only when being evaluated, meaning that the environmental programme was unstable.

The hospitals still suffer from serious environmental impacts from the construction of new buildings, internal traffic congestion, mixed waste, and resource over-use (particularly utilities and office supplies). Although staff have good environmental knowledge, poor awareness has appeared to be a key barrier to successful deployment of environmental knowledge and practice. Other important barriers include:

- The government paper system increases the amount of paper used,
- Increasing volumes of patients are challenging in reducing resources, particularly medical resources,
- New IT systems (e.g. HOSxP and e-GP) raise the use of computer supplies and paper. And, these poorly-developed systems often bring errors, low integration and transfer of data and instability,
- Pharmacy departments have to meet a 1-2 month turnover rate (which is not 3 months as mentioned by the MOPH) and to reduce cost by 10%. But, these have brought stock shortages and internal conflict among professionals.

- A shortage of resources (e.g. chemical solutions and medicines) has directly resulted in poorer quality of medical services.
- Increasing single use medical devices, mandated by the MOPH, have brought a larger volume of waste and handling cost.

Hospitals cannot provide a clear environmental direction because key eco-aspects are unknown such as the cause of increasing utility costs. Some suggested that Thai researchers should investigate ways to minimise waste volume and indicators to measure efficiency. When asked about the possibility of addressing GL, the hospital Director said that, *"Thailand still lacks green vendors, and the knowledge about logistics and the environment. As a result, I believe it is very difficult to address GL in Thai hospitals"*. About the green supply chain, many respondents said that their hospitals have insufficient authority to motivate suppliers or customers. Lastly, it was found that both the Director and staff were willing to be research participants.

<u>Key Logistical Flows</u>

There are two main logistical flows, which are patients and resource/waste. They are supported by two minor flows, financial and information. All flows drive clinical operations and supporting activities forward. Several types of resources were mentioned associated with patient flows: pharmaceutical products, medical supply and medical equipment, office supply and office equipment, food materials, linens, chemical substances and utilities. After being used, these resources are turned into general waste (GW), infectious waste (IW) and sharps, hazardous waste (HW), recyclable waste, food waste, and wastewater.

<u>Patient Flows</u>

The patient flow starts at a registration unit. This unit screens this 'outpatient' and sends him/her to a clinical treatment or to other diagnostic procedures (e.g. x-ray and blood test). After that, the physician decides whether to let the patient be admitted to the ward, or to receive medicine and/or go home, or transfer to another hospital.

When a patient is admitted to a particular ward, he/she will be called an ‘inpatient’. And, multiple hospital services, such as the operating theatre, laboratory, rehabilitation, catering, linen, and pharmacy, get involved. This means various types of resources are encountered in the clinical-care operation. Also, the flows of information (such as medical records and inventory records), and finance (such as a clinical service fee) move simultaneously with inventory and patients from the beginning to the end. These are either recorded in a paper system or IT system or both, depending on the hospital.

Resource Flows

The inventory flow involves submitting requisitions, purchasing, receiving purchased resources, storing, distributing, and disposing of waste. Mostly, these processes are highly reliant on paper systems and require several approvals consistent with regulations. However, this can be supplemented by IT systems. The stock controllers of these resources are as follows:

- Office supply: Administration Department or Supply Office
- Medicine and new medical supply: Pharmacy Department
- Reusable medical supply: Central Sterilisation Unit
- Linen: Laundry Department
- Foods: Nutrition Department
- Chemical solutions: Laboratory Department

Normally, the hospital contacts a number of suppliers and lets those departments who control stock select and distribute resources. All hospital departments can be both users and waste generators. Users will be asked to submit a resource requisition form and collect orders according to the schedule, e.g. every 2 weeks. This differs from hospitals in high-income nations that use small numbers of suppliers, IT-based, centralized warehouses to store all hospital resources and distribute resources on a daily basis (e.g. NHS Supply Chain, 2012).

Stock shortage is frequently found, with causes such as: (i) the Government Pharmaceutical Organization (GPO) often has problems of production and late delivery; (ii) the hospital has many approval processes that bring late purchasing and delivery; and (iii) stock controllers manage resources poorly. Examples of solutions are purchasing from local suppliers or borrowing items from nearby hospitals.

Waste Flows

Many hospitals have followed the Infection Control Guidelines and Hospital Accreditation (HA), for effective waste segregation and management. However, the accuracy of waste sorting varies by according to the hospital implementation. After the waste is sorted in, for example, wards and departments, a housekeeping worker will collect them to store in the waste storage room. General waste (GW) is usually received by the municipality. Infectious waste (IW) and hazardous waste (HW) can be incinerated by private companies, the municipality or the hospital. Old equipment is kept in the maintenance department to be approved for discarding and resale later. The recyclable waste or reusable waste is either reused by the hospital or sold. Waste water is generally cleaned by a hospital wastewater treatment plant before releasing. Reusable medical devices are sterilised for disinfection by the Central Sterilisation Unit, or at particular departments (e.g. operating theatres). Used linens are washed, dried and stored at the Laundry Department. Lastly, food waste is often fed to hospital animals, or given to farmers to feed their animals.

(iii) The Development of the Hospital Logistics Diagram

From the outcomes of interviews and preliminary review, the hospital logistics diagram can be developed as shown in Figure 3-4 below, which represents the main flow of hospital logistics. This research focuses mainly on patient and inventory/waste flows because they drive financial and information flows forward.

The diagram shows that many resources are moved from suppliers to their responsible departments of the hospital. After that, these resources are distributed to many areas such as wards, clinics, and offices. Some are directly used in the clinical treatment process such as medical supplies and medicine; while some support treatment such as foods, linens and chemical solutions. These resources turn into waste after use, sorted into several types for the purpose of proper handling by the hospital cleaning procedures, incineration or 3rd parties.

The hospital logistics diagram is supplemented by Table 3-3, which explains and summarizes hospital inventory and waste streams. For example, the Pharmacy Stock controls all types of medicine, which are later distributed to other areas such as wards and clinics. If these medicines have expired or deteriorated, they become hazardous waste. Tablets are later disposed of for example, incinerated, while liquid medicine is classified as waste water which is processed by the hospital wastewater treatment. These wastes can be handled by the pharmacy department or nurse station.

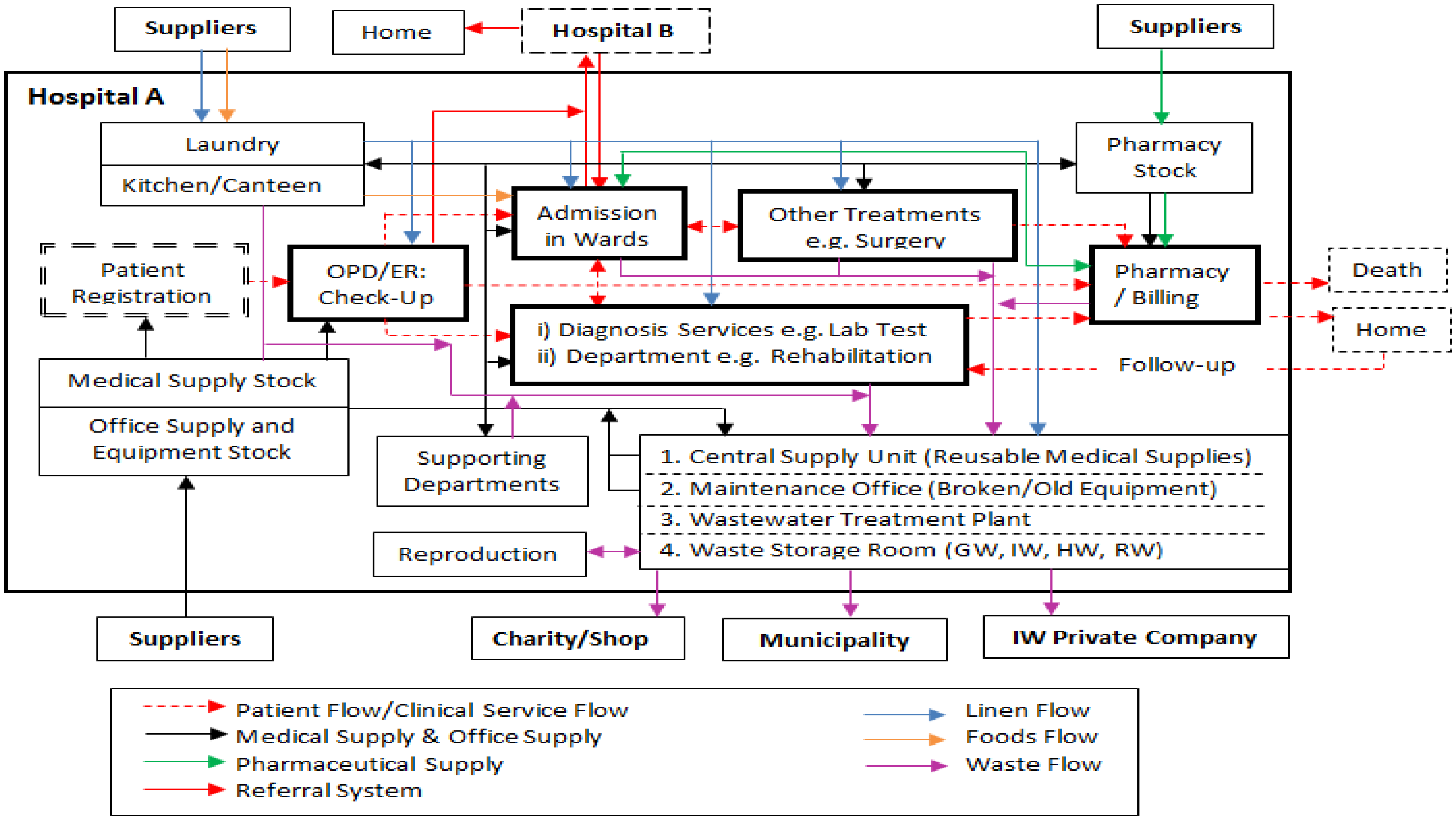


Figure 3-4: Thai public hospital logistics diagram.

Source: Author.

Table 3-3: Resource and Waste Streams in Thai Public Hospitals.

Resource	Example	Main Source	Waste Type	Collector
1. Pharmaceutical	Pills, capsule, portion	Pharmacy Dept. , wards, clinics	- HW - Waste water	- Pharmacy Dept., or Nurse Station - Sewage System
2. Medical Supply	Glove, blade, syringe, gown, drape, gauze, IV tubing, mask, bandage	IPD, OPD, Operating Theatre, etc.	- Sharps - IW (single use, multiple use) - GW	- Housekeeping Worker - Worker of Central Sterilisation Unit
3. Medical Equipment	OR table, monitor, wheelchair		- GW/HW	Maintenance Dept.
4. Chemical Substances	Chemical agents (solid, liquid), cleaning products	Laboratory, and Housekeeping Unit	- HW - Waste water	- Housekeeping Worker - Sewage System
5. Office and Housework Supplies	Paper, stationery, waste bags, tissue paper, detergent	Administration, physician office, pharmacy department, nurse station, etc.	- GW (Reuse/ Recycle) - GW (single-use) - HW - IW	Housekeeping Worker
6. Office Equipment	a) Furniture, computers, electric equipment, desks b) batteries, cartridges, lamps			Maintenance Dept.
7. Kitchen Materials	a) Dishware, kitchen materials, containers b) Food materials	Kitchen and Canteen	- GW (Organic, Reuse/Recycle) - Waste water	- Housekeeping Worker - Kitchen Worker - Sewage System
8. Linens	Patients' clothing, towels, blankets, surgical wraps	Laundry	- Infectious linens - General linens	- Laundry's Worker
9. Utilities	a) Water b) Energy (such as LPG, Diesel, biogas) c) Electricity	All Departments	- Waste water - Air emissions - Used oil/fuels	- Sewage System - Maintenance Worker

(iv) Discussion of Public Hospital Green Logistics

The outcome of the preliminary overview indicates that in order to effectively control resources and waste in Thai hospitals, further developments need to take place, for example, the creation of appropriate guidelines, policy adjustment and monitoring regimes drawn up and actioned. The outputs of this analysis clearly indicate that resolving the waste problem is complicated and onerous, as shown in Figure 3-4 and Table 3-3.

From the findings presented, there are clear departments and personnel involved in the logistics flow in Thai Hospitals. This can help focus improvement efforts by allocating tasks to the correct personnel in key departments. For example, if the hospital would like to sort waste properly in order to reduce the mixed waste problem, the hospital has to liaise with supply stockists, users (e.g. nurses and physicians), patients and visitors, and housekeepers. Waste segregation could be more effective if the housekeeper, who is the actor at the end-of-pipe of waste streams, frequently checks the waste and can provide feedback to users and stockists. This practice needs support from the Hospital Director according to the Thai organizational system.

3.4 Review of International Healthcare Practices

A review of current practice in Thai hospitals has presented detailed information regarding the current environmental policies and outcomes, logistics operations, and key environmental aspects. However, the management of such environmental aspects appears incomplete. Therefore, sections 3.4-3.6 explore related knowledge to GL adoption covering: drivers/barriers to adoption and success, hospital logistics and supply chain management, implementation strategies and practices for resource allocation/consumption and waste management.

(i) Drivers and Barriers of Green Logistics in Healthcare Systems Globally

This section focuses on three areas that act as drivers and barriers to adoption of hospital environmental management (HEM), and its implementation practices. The presentation in this section follows EMS – ISO14001, of which NHS (2001, p.15) commented that ISO 14001 is widely implemented and less onerous.

Note that details of GL practices are presented in sections 3.5 and 3.6

Drivers and Barriers of International Healthcare

Starting something new may bring many challenges, because it generates a new level of work and responsibility, a change of practice, and requests for resources for systems that are already maximized (Bisson et al., 1993). Accordingly, leadership and top-level commitment are noted as the major drivers of change (e.g. Hall, 2008, HCWH, 2011), indicating that the administration is supportive of it (Bisson et al., 1993). In NHS organizations, drivers include organizational factors and regulation, while there are such barriers as cost and lack of legitimacy (Walker et al., 2008). Among US Hospitals, Hall (2008) pointed that ineffective regulation, insufficient support from government, low staff commitment, and poor education and communication can be obstacles.

Implementation of GL Practices in Hospitals

In order for a hospital to effectively introduce and sustain GL practices, it is advocated that they should start with administrative support, followed by assigning roles and responsibilities in which environmental committees may be established (Bisson et al., 1993). Their duties include; (i) arranging guidelines and strategies; (ii) providing education and training programmes; (iii) overseeing and evaluating the programme; and (iv) working with third parties. In keeping with quality and change management initiative, the green programme should be part of everyone's job including housekeeping/environmental workers, purchasing department, nurses and physicians.

Videos, posters, handbooks, group meetings, newsletters, email, and display cases are examples of effective communication methods. The organisations should be aware of the importance of education and updated information on matters such as hazardous materials, level of risk, and disposal policies (Göçer and Tuna, 2013). In addition hospitals should realise that the public does not work at the hospital and will not gain benefits from the green programme (Bisson et al., 1993). Johnson (2010) mentioned that although healthcare issues (e.g. cost and quality) remain on the key healthcare policy, some hospitals have moved forward to not only address green issues, but also add incentives to support employee, patient and visitor satisfaction.

Bisson et al. (1993) recommended hospital tours to conduct a comprehensive assessment in order to get actual feedback and to know about special needs and processes. This includes collecting relevant documents (e.g. waste management cost), contacting one-to-one, mapping resource and waste flows in departments, and recording (e.g. unexpected findings, running ideas, problematic areas and potential solutions).

(ii) International Healthcare Supply Chain and Logistics

Healthcare Supply Chain

The hospital has to coordinate with producers (e.g. pharmaceutical/surgical manufacturers), purchasers (distributors), patients, and waste dealers/collectors (Burns, 2002). The healthcare industry has unique characteristics, such as outputs based on the current daily patient census, and a greater number of stock-keeping units (Jarrett, 2006). The end customer (patient) is not the decision maker, but the physician (Nachtmann and Pohl, 2009). Hence inventory management problems such as excess, obsolete/outdated inventory, unused inventory, and shortages can occur (e.g. Breen and Crawford, 2005, Kumar et al., 2008).

Factors such as quality of information and its exchange, integrity, and availability of materials can impact the quality of the healthcare supply chain (Smith et al., 2011). Good healthcare supply chains generate smooth distribution to all hospital departments, and cost reduction, as stated by Hootajuta and Poonnakitikasem (2010). A healthcare green supply chain is not only about purchasing environmentally-friendly products, but looking at how the hospital has incorporated suppliers in addressing the ‘environmental mind-set’ in their planning and decision making (Hall, 2008).

Healthcare Logistics

The hospital logistics operation involves bed management, information management, the blood supply chain, scheduling appointments and operating theatres and resource utilization (Vissers and Beech, 2005, Vanichchinchai, 2012). Good inventory management should have the following characteristics: lower numbers of inventories/stock shortage/outdated items, standardization of inventories at low cost, high turnover rate of inventories, and a low number of suppliers (Aptel and Pourjalali, 2001, Jarrett, 2006, Pan and Shaligram, 2007).

The following practices imply effective inventory systems: regular random checks, scheduling of requisitions, using first-in first-out (FIFO) systems (or first-expire first-use), adopting real time replenishment systems and/or vendor managed inventory (VMI), using stock cards and coloured boards, and sequential ordering, associated with Strashok et al. (2010).

E-logistics (e.g. central database) is generally addressed to integrate and exchange data between departments, such as patient identity, lab test results, and finance (Pine et al., 2012). The data is also exchanged with trading partners (Kim et al., 2006). Better information systems can support decision making, such as sharing information for physicians having the same patients (Ayers et al., 2009) as well as discharging, financing and drug use (e.g. Poston et al., 2007, Ayers et al., 2009, Ginn et al., 2011).

3.5 Environmental Practices for Key Hospital Resources

This section seeks to understand the main resources of healthcare in general, and how the hospital reduces their environmental impacts. Key resources include medicines, medical supplies, food and catering materials, office supplies (including paper), utilities (electricity, energy and water), linens, and equipment. Since Thailand's knowledge regarding environmental management on the whole was not extensive, it was supplemented by knowledge at international level.

(i) Introduction to Resource Management

The amount of resources that hospitals consume is driven by the number of inpatients and outpatients, equipment used, facility size, number and types of service, facility age and maintenance requirements (ESC, 2003, p.12). The 3Rs Concept is largely applied, by which: (i) 'reduction' decreases the volume of waste generated at source; (ii) 'reuse' prolongs the life of a material; and (iii) 'recycling' reuses waste as new product inputs, but does not have shorter-term benefits (ESC, 2003) . The 'avoidance' concept or prevention strategy is much recommended to more effectively minimize materials entering the hospital rather than focusing on waste control (see Figure 3-5).

Figure 3-5: Prime waste-management criteria.
Source: ESC (2003, p.25).

(ii) Hospital Resources and Their CO_2 Emissions

Thailand's Department of Health (DOH) has encouraged public hospitals to calculate the volume of carbon emissions. Such emission reductions are achieved by reducing volumes of resources used and waste generated. Below are the formulas for calculation of CO_2 emissions (DOH, no date, Dalgaard and Halberg, 2007, Cuéllar and Webber, 2008, University of Exeter, 2013, Hahn, 2013).

- Electricity (kWh) emits 0.5610 kgCO_2/kWh
- Diesel fuel (liter) emits 2.68 kgCO_2/litre
- Petrol or gasoline emits 2.31 KgCO_2/litre
- LPG emits 1.51 KgCO_2/liter (1 kg of LPG equates to 1.96 litres or 2.96 KgCO_2)
- LNG emits 3.14 KgCO_2/kg
- Fertilizer from waste fermentation emits 0.177 kgCO_2/kg
- Food waste biogas emits 0.21 kgCO_2/kg
- Manure biogas emits 1.8 kgCO_2/liter or 0.58 kgCO_2 per 1 kg of manure
- General waste management by landfill emits 0.8421 kgCO_2/kg
- Paper emits 5.4 kgCO_2/ream

(iii) Medicine

The study of Soroslikhit et al. (2008) shows that reducing use of medicine by supporting health promotion can reduce the re-medication rate for seven days from 2 to 0.01 percent. Thus, the hospital should reconsider prescribing and dispensing systems asking *'do they contribute to surplus supply of medicines'?* (Zermansky, 1996, Millar et al., 2003). Reducing medicine is recommended in the case of overuse or irrational use. For example, overuse of antibiotics is associated with antibiotic resistance (Goossens et al., 2005). Some practices, like practising mindfulness that reduces stress, pain and blood pressure, appeared to be effectively reducing medicine, healthcare cost and improving health (e.g. Olivo et al., 2009, Rosenzweig et al., 2010, Gregoski et al., 2011, Schneider et al., 2012).

Many Thai public hospitals have introduced a returned medicine programme, particularly tablets in the proper packaging. This programme offers substantial reductions of both medicine volumes and financial cost. Utilizing modern packaging techniques that react to temperature and humidity would be possible to identify inappropriately stored medicine (ICH, 2003). Hence, this can suggest the potential to re-use medicines, particularly in developing nations where medicines are not widely available (Mackridge and Marriott, 2007). The hospital should also implement pharmaceutical recycling, which Xie and Breen (2012) revealed that can lead to savings and reduce waste.

(iv) Medical Supply

Several laboratory materials cannot be reused/recycled such as slides, pipettes, and chemical containers (Bisson et al., 1993). Hospitals often reuse single-use medical devices for cost effectiveness. But many studies suggest avoiding this practice, because, for example, the devices remained contaminated after cleaning and most hospitals did not routinely review adverse events even if they had a surveillance system (e.g. Roth et al., 2002, Amarante et al., 2008, Hailey et al., 2008).

Over-ordering of lab tests by physicians has generally occurred. It is because test results are considered more significant than physician examination and physician fears of failing to notice something important (Axt-Adam et al., 1993). The large number of lab tests was a matter of convenience and relied on clinical acumen, patient discharge, or physicians’ memories to discontinue those orders (Neilson et al., 2004). These authors suggested that providing feedback on the number and costs of tests can stimulate cost-conscious behaviour.

(v) <u>Electricity and Energy</u>

<u>Electricity and Energy</u>

Energy consumption makes up a significant portion of a hospital's footprint, because the hospital needs energy to heat, cool, and power their facilities and clinical processes 24 hours a day (ESC, 2003). The energy includes electricity, natural gas, and fossil fuels. Currently, Thai electricity generation is highly dependent on natural gas (71%), followed by coal (21%) (Ministry of Energy, 2012). Minimizing electricity usage therefore relates to the reduction of air emissions, owing to its production needs regarding the combustion of fossil fuels. The tropical climate of Thailand has led to high or excessive use of electricity for air conditioning systems, which can be half of total electricity usage (DOH, 2012). Accordingly, air conditioning should be the key target for reducing electricity consumption. Identifying areas/equipment/systems that have maximum energy consumption should be followed by action such as buying and installing energy-efficient equipment (ESC, 2003).

<u>Renewable Energy - Biogas Production</u>

Biogas or methane is a clean-burning energy, which is used for heating, cooking, transport, and power generation (Addison, 2013). It is produced by the fermentation of wet biomass (such as plant material, animal excrement, residues from agricultural and food production, and waste materials) under the exclusion of oxygen (Gerlach et al., 2013). According to the Ministry of Energy (2013), one cubic metre of biogas can replace 0.46 kg of kitchen LPG or 0.60 litre of diesel fuel, and produce 1.20 kWh of electricity. It can replace kitchen LPG, and boil 130 litres of water as well as cook three meals for a family of four.

A produced biogas contains only 55-65% methane, which is lower than natural gas with 80% methane (Addison, 2013). Therefore the heating value of biogas is only 21 BTU per litre, while natural gas offers 35 BTU per litre. This has brought problems of low heating value and pressure.

(vi) <u>Water</u>

Hospitals are significant consumers of water, and generate a considerable amount of wastewater which consists of, for example, pathogens, pharmaceuticals, and toxic chemicals (Christian, 2012). Christian also presented the proportion of water use as follows: sanitary (41%), HVAC (or heating, ventilation, and air conditioning) (22%), medical processes (14%), food services (9%), laundry (5%) and miscellaneous (9%). The hospital usually utilises five types of water: (i) tap water (for, for example, kitchen, laundry, sanitary); (ii) filtered water (for, for example, drinking); (iii) purified water (for, for example, dialysis clinic and specimen processing equipment); (iv) grey/black water (or waste water); and (v) clean wastewater (Total Water, 2011, Christian, 2012).

There are many water saving practices such as checking for any leakage, installing meters and water-saving devices, turning-off water when not in use, growing more drought-resistant plants, washing linen when needed and reusing waste water from laundry and sewage systems for gardening (WHO and HCWH, 2009, Strashok et al., 2010, Earth Easy, 2012).

<u>Reusing Wastewater</u>

According to WHO and HCWH (2009, p.21), onsite sewage treatment plants will filter and capture wastewater for re-use in toilet flushing, cooling plants, and interior and exterior garden irrigation. But this treated wastewater should contain no more than one helminths eggs per litre and no more than 1,000 faecal coliforms per 100 ml (Prüss et al., 1999, p.132). The Renewable Energy Centre (2013) claims that this practice requires extra equipment to pump and collect this greywater. In Songklanagarind Medical School, Thailand, Puetpaiboon (2002) investigated reusing clean wastewater and revealed that it is practical and theoretically feasible for watering plants.

(vii) Office Supplies, Particularly Paper

Paper is the key category of office supply, because all public hospitals must rely on the government paper-based system. Using 1 ream of paper equates to 6% of a tree, 5.4 kg of CO_2 and 160 litres of water (Avoka Blog, 2009). In Thailand, if used paper is not reused or recycled, paper waste generally ends up in landfill. Thus, consuming less paper, reusing/recycling paper and selecting eco-friendly paper are ecologically meaningful and cost cutting. The World Wildlife Fund (WWF, 2013) suggested:

1. Encourage staff to review meeting documents on computers,
2. Make sure that meeting participants have electronic access to all the materials beforehand, and use electronic communications (e.g. email),
3. Use both sides of a sheet of paper, whether for copying or printing,
4. Change computer default settings to put more text on each page,
5. Use lower grammage paper, heavier weight sheets use more fibres and cost more per sheet, and,
6. Provide desktop recycling containers for employees.

(viii) Procurement

Procurement or purchasing is the main area to encourage totality life cycle (FHNW, 2013, p.37). Consequently, these practices should be applied: (i) selecting green products which are less toxic, recyclable, reusable, organic, use green energy, are energy saving and local; (ii) buying only what is needed; (iii) buying in bulk; and (iv) choosing products with as little packaging as possible.

(ix) Transportation

Hospitals are highly transportation intensive organizations, because of large volumes of vehicles (from staff, patient, and hospital), producing high air pollution, noise and particles (HCWH, 2011). Green transport practices include using alternative fuels, selecting alternative modes of transportation (e.g. bicycle, walking, and public transport), adopting electronic communication (e.g. telemedicine and e-mail), and training in "eco-driving", as stated by Strashok et al. (2010).

(x) <u>Green Building</u>

Green building design and construction should be addressed (WHO and HCWH, 2009). Its practices include allowing more natural light into rooms, installing environmentally friendly wall and floor coverings and using green cleaning products; which offer benefits such as fewer medication errors and shorter patient stays/quicker recovery times (Hall, 2008, p.41).

(xi) <u>Organic Food Materials</u>

Many studies indicated that health, food safety and environmental concerns are the main motives for organic food purchases (e.g. Magnusson et al., 2001, Harper and Makatouni, 2002). Buying organic and locally-grown food materials will support local economies and sustainable healthy food systems, as mentioned by Hall (2008). Although Dangour et al. (2009) revealed no evidence of a difference in nutrients between organically and conventionally produced foods, it can ensure that fewer pesticides are used (Forman et al., 2012).

There are some limitations of the organic food market, including a small number of vendors, seasonal dependency, short-term economic failure, lack of information, not meeting certain customer demands and vulnerability towards incoming 'green' supermarkets (Stagl, 2002). The most common belief about organic foods is that they are more expensive, which makes the proportion of regular purchasers low (Magnusson et al., 2001). Thus, the organic market can take advantage of research on the above limitations to buy its products. Healthy eating habits are the key practices adopted by the healthcare sector. Hospital menus can be changed to have fewer meat and dairy products, to produce food on-site, increase the proportion of organic foods and donate daily excess food (WHO and HCWH, 2009, p.19). They help reduce GHGs from feeding cattle and transportation.

(xii) Packaging

Using cloth bags and reusable food containers are suggested. A cloth bag can be reused several times, which reduces a large volume of plastic bags. Generally, plastic production generates a large amount of carbon dioxide (West, 2013) and it often ends up in landfills and hardly decomposes; only a small proportion of plastic bags are recycled.

(xiii) Linens

Linen is a general term for clothing items, including blankets, bed sheets, blue sheets, patients' clothes, gowns and towels. Some have to be cleaned every day such as bedding and patients' clothes. The Laundry Department is responsible for providing sufficient clean linen to all users (e.g. ward, clinic and laboratory), by cleaning, stocking, distributing and mending torn linen. The Laundry's key objective is to control hospital infection (Gajuryal, 2014). Manufacturing, use and maintenance of linen increases consuming energy, water and chemical products (Green Choices, 2013) so that reducing the amount of linen used directly minimizes environmental impacts. Washing at lower temperature emits lower CO_2 than higher temperature (Berners-Lee and Clark, 2010). For instance, washing at 30°C emits 0.6 kg CO_2, while using 60°C emits 3.3 kg CO_2. The lifetime of linen is about 2 years. Inadequate linen availability means the same linen is washed and dried at high temperature every day, greatly reducing its lifespan (BC Textile Innovations Inc., 2010). Linen should be allowed to rest for 24 hours before being placed back into service (Gajuryal, 2014). Gajuryal (2014) suggested having 4-6 sets of linen: one in use, one ready for use, one being processed, one in transit and two for weekends. This is also consistent with the MOPH's policy. To extend linen's life it is also necessary to use more environmentally-friendly washing products.

3.6 Environmental Practices for Key Hospital Waste

This section generically explores hospital waste, categories of waste and waste management practices. The WHO provides the hospital waste management guidelines (sections 3.6 (i) and (ii)) which influenced Thailand's practices (section 3.6 (iii)).

(i) <u>Introduction to Global Waste Management Practices</u>

Hospital waste was defined by the WHO (2011) as a byproduct of healthcare that includes sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials. 80% of hospital waste is general waste (GW), while the remaining 20% is considered hazardous material that may be infectious, toxic or radioactive. In general, hospitals' waste volumes vary depending on the time of day, case load, renovation schedule, and so on (Bisson et al., 1993). University hospitals generate the highest volume of waste (4.1-8.7 kg/bed), followed by city hospitals (2.1-4.2 kg/bed), and district hospitals (0.5-1.8 kg/bed) (WHO, 1999, p.13).

General waste (GW) is mostly collected in trash bins and disposed of in municipal landfills (HCWH, 2001, pp.11-12). Figure 3-6 presents the typical composition of hospital GW, of which the major proportion (45%) is accounted for by paper and paperboard. Many types of GW can be reused and recycled.

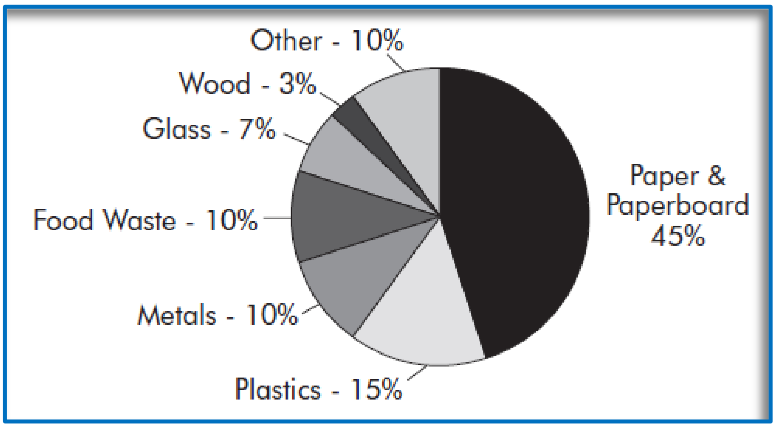


Figure 3-6: Hospital solid waste composition in general.
Source: HCWH (2001, pp.11-12).

Concerning hazardous waste (HW), the WHO (2011) classified it into 10 subcategories (see Table 3-4). As stated earlier, within that 20% of HW contains pathological and infectious waste (15%), chemical or pharmaceutical waste (3%), sharps (1%) and the remaining 1% includes radioactive or cytostatic waste, pressurized containers or broken thermometers and used batteries.

Table 3-4: Categories of Healthcare Waste by WHO.

Waste category	Description and examples
Infectious waste	Waste suspected to contain pathogens e.g. laboratory cultures; waste from isolation wards; tissues (swabs), materials, or equipment that have been in contact with infected patients; excreta
Pathological waste	Human tissues or fluids e.g. body parts; blood and other body fluids; fetuses
Sharps	Sharp waste e.g. needles; infusion sets; scalpels; knives; blades; broken glass
Pharmaceutical waste	Waste containing pharmaceuticals e.g. pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties e.g. waste containing cytostatic drugs (often used in cancer therapy); genotoxic chemicals
Chemical waste	Waste containing chemical substances e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents
Wastes with high content of heavy metals	Batteries; broken thermometers; blood-pressure gauges; etc.
Pressurized containers	Gas cylinders; gas cartridges; aerosol cans
Radioactive waste	Waste containing radioactive substances e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources

Source: Prüss et al. (1999, p.3).

The WHO (1999) suggested eight waste treatment techniques such as thermal process and chemical disinfection; each category of HW can be handled by one or several techniques (see Table 3-5). Incineration can destroy viruses or microbes contained in medical waste, but the poor quality of incinerators releases toxic pollutants and heavy metals from fly ashes (Singh and Prakash, 2007, Inazumi et al., 2011, Xie and Zhu, 2013).

(**Note**, in Table 3-5, high t is the abbreviation for high temperature.)

Table 3-5: Treatment and Disposal of Hazardous Waste by WHO.

Treatment Technique	Infectious	Sharps	Pharmaceuticals	Chemical	Cytotoxic	Pressurized	Radioactive
Thermal Process	/	/	/ (high t)	/	/ (high t)		
Wet Thermal Disinfection	/	/					
Containment Process							/
Chemical Disinfection	/ (burial)		/ (burial)	/ (burial)		/ (burial)	
Discharge to Sewer			/				/
Return to Suppliers			/	/	/	/	/
Export to Expertise Countries				/			
Chemical Degradation					/		

Source: Modified from WHO (1999, pp.167-180).

(ii) Importance of Waste Segregation

According to the WHO (Prüss et al., 1999), HW management includes six key elements: waste classification, waste segregation, waste minimization, containerization, colour coding, and labelling and signage. All staff, especially nurses, support staff and cleaners, particularly those who work in areas such as wards, treatment rooms, operating theatres and laboratories, should be trained to sort the waste they produce. Careful waste segregation and separate collection can reduce the waste volume that requires specialized treatment (WHO, 2011). Jang et al. (2006) stated that such practice also reduces toxic air pollutants from incineration because many plastic materials are sorted out. Heavy metals such as mercury and lead can also be removed for appropriate disposal (Hall, 2008).

(iii) Thailand's Waste Management Practice

This section discusses Thailand's waste handling guidelines for infectious waste, pharmaceuticals and medical supplies (reusable type).

Solid Waste (Infectious and Hazardous Types)

Hospitals generally sort waste into five types: general waste (black bag), recyclable waste (green/white bag), infectious waste (red bag), hazardous waste (grey bag) and sharps (strong containers) (Chulabhorn Hospital, 2013). There are hospital measures such as: all staff being responsible for sorting waste properly; all cleaning personnel having to wear protection correctly; and waste must be collected and stored in the waste storage room (see Figure 3-7).

The Pollution Control Department (PCD, 2010) has termed IW as body parts or carcasses of humans, and sharps (e.g. needles, blades and syringes), materials contaminated with blood, blood components and body fluids, and waste from wards. HW and IW are often managed by three methods: thermal disposal/incineration, secured landfill, and integrated disposal facility. The Full IW Handling Guidelines are in Appendix 4.

Figure 3-7: Infectious waste handling guidelines.
Source: PCD (2010, pp.53-54).

Medicine Waste

Medicine waste contains four categories: medicines left over; nearly expired medicines; deteriorated medicines; and expired medicines. These are controlled by the coordination of purchasing officers, drug stores, and department users (Visuttikhun, 2012). Pharmaceutical waste is hazardous. Pills and capsules have to use thermal processes or safe landfill, while liquids need to be diluted before being discharged into hospital sewage systems (Ministry of Public Health, 2008).

Before the formal disposal of pharmaceutical waste, it must be approved by the Regional Revenue Department and Provincial Health Office. Lastly, nearly-expired and deteriorated medicines that have a shelf life longer than 6-7 months can be exchanged with suppliers (Visuttikhun, 2012). Visuttikhun also suggested that to reduce expired items and shortage, the hospital should provide more frequent checking on shelf-life and distribution, reduce the volume reserved (e.g. on wards), focus on first-expired first-out (FIFO), and periodically record nearly-expired items to remind staff to use them in order.

Reusable Medical Supplies

The Central Sterilisation Unit or Central Supply Unit decontaminates and sterilises reusable medical devices and equipment (e.g. stainless steel tools), procedure packs, and distributes clean devices to users (e.g. wards, operating theatres, clinics and emergency room) (Bamrasnaradura Institute, 2010).

Used medical devices are firstly cleaned using a washing detergent or chemical solution. This is followed by packing into sets, to be later disinfected and sterilised. The unit is divided into clean zone, dirty zone, and sterile storage zone. Workers have to wear proper protection, including thick rubber gloves, long boots, hat, mask, waterproof apron and face shield. Sukkaew (2010) discovered that establishing a sterilisation unit in the operating theatre (in large-sized hospital) can support an operating schedule that has many planned cases a day and emergencies.

3.7 Conclusions

The aim of this study is to examine GL adoption in Thai public hospitals, therefore the boundary of research is set as ‘studying GL in Thai hospitals’. The research focus is the examination of key logistics activities inside the hospital, rather than the entire healthcare supply chain (as per the reasons outlined in section 3.2 (v)). This research agenda is also associated with the 2nd National Logistics and Supply Chain Research Strategies (2012-2016).

As shown in this literature review, Thai research outputs to date highlight several problems in this field including mismanagement of waste, overuse of many resources, poor logistics and supply chain systems, and low financial liquidity (e.g. Tangcharoensathien et al., 2010, PCD, 2013b, PCD, 2013c). The main tool to further the environmental agenda in Thai hospitals, as advocated by the Thai government, is the ‘GREEN and CLEAN’ policy, however it itself has several barriers to adoption, such as unclear implementing strategy and indicators. This issue plus other gaps as outlined in this chapter confirm the need to observe hospital GL adoption in Thai hospitals.

In order to do that, however, it needs a clear understanding of: (i) the hospital logistics operations; and (ii) the current environmental performance. Still, such knowledge is very limited. Thus, undertaking ‘a review of current Thai hospital practices’ is necessary; this includes both the literature review and personnel interviews. The discussion of the study outcomes is as follows.

<u>First outcome: Hospital Green Programme</u>

Although several hospitals have embedded a green programme according to HA requirements, problems such as overusing of medicine and mixed waste are continuing and growing. The initial causes of problems are, for example: (i) hospitals lacking the knowledge of life cycle assessment; (ii) the government providing ineffective regulation and monitoring; and (iii) hospital personnel having poor environmental awareness.

Therefore, this highlights the needs of GL adoption. For effective adoption, more in-depth study is needed to clarify causes of problems and identify successful solutions (best GL practices). Because the financial problems were noted by most respondents, GL adoption should be grounded in the SEP concept that consists of, for example, economical use of resources, self-reliance and sustainable direction.

Second outcome: Hospital Logistics Activities

Key hospital resources and waste were clarified, and their complicated movements inside the hospital were mapped (see Figure 3-4 and Table 3-3). This indicates that addressing GL may be complex as GL practice involves many activities, targeted departments and personnel. The preliminary analysis presented in this chapter shows that several areas/practices within Thai hospitals are highly ineffective such as paper-based systems and returned medicine flow, which affect the medical services provide (e.g. long lead time).

Thus, review and informed restructuring of Thai hospital logistics is needed, as well as a more profound study of each logistical flow (e.g. each category of resources and wastes). This review should be supported by a more comprehensive insight into hospital culture and practice, to determine their impact on resource and waste management.

This is associated with the set research boundary of focusing on both physical and human elements, which will be discussed in Chapter 4.

Chapter 4: Research Methodology

This chapter begins by presenting the research aim and questions, as established by a review of literature and current Thai hospital practices. It clarifies several definitions (e.g. best practice and environmental practice) and research boundaries, followed by the development of research indicators. The methodological approach and data collection tools employed will also be introduced and discussed. This will be followed by an insight into the data analysis methodology, identification of best practice, pilot study and selecting case organizations and, finally, a summary.

4.1 Introduction to Research Methodology

(i) <u>Research Focus</u>

In Chapter 3, a review of current Thai hospital practices was conducted in order to understand the following areas in Thailand's public hospital context: (i) overall environmental policies and practices; (ii) key logistics functions and flows; and (iii) key hospital resources and waste. The study found the need to undertake a hospital visit in order to profoundly understand such issues as effective GL practices, personnel's view and all functions in each of the resource and waste flows.

Knowing these could help to find out 'the best practice' that successfully minimizes the overuse of resources, or mismanagement of waste, or financial crisis. This is according to the requirements of the 2nd national research strategies. Moreover, the outcomes of a THP preliminary study informed the main research agenda, the methodology of which is discussed within this chapter.

(ii) Research Aim

The aim of research is:

'To identify Green Logistics best practice leading to the efficient management of resources and waste in Thailand's public hospitals'.

This research study contributes to the Thai Government Green Agenda as promoted by the Department of Health, and the 2nd National Logistics and Supply Chain Research Strategies.

The best practice in this study refers to the practice that has the best performance in managing resources and waste among other case hospitals (or with regards to this PhD thesis's sample mean). Also, the best practice refers to the practice that we can learn from.

Moreover, the research looks at best practice in terms of operational activities and implementation approach. It considers hospitals' different features including hospital type, size, location, timeframe, resource and background.

As informed by the extant literature reviewed in Chapters 2 and 3, the exploration of GL adoption in Thai hospitals should cover four key dimensions: (i) environment; (ii) social; (iii) economic; and (iv) logistics. This study proposes that both human and physical elements are included in the research.

(iii) Five Key Research Questions

The research aim can be classified as a benchmarking process, which Wöber (2001, p.4) defined as, "a systematic procedure of comparative measurement with the objective to achieve continuous improvement". Hence, two key questions need to be addressed: 'Who is the best?' and 'What factors and practices lead to success or failure?'

In keeping with above aim, five research sub-questions can be set as:

1. **What are the most important study areas in Thai public hospitals?**
2. **How should we measure the GL performance of Thai public hospitals, in the areas identified in 1?**
3. **Which Thai public hospitals are performing best on each measure?**
4. **What practices are allowing Thai public hospitals to best perform?**
5. **What are the barriers to addressing environmental programmes in Thai public hospitals?**

(iv) Terminologies and Definitions

Certain terminologies are widely used in Thai public hospitals, when talking about addressing environmental management:

Best Practice: "A technique, method, process, activity, incentive, or reward which conventional wisdom regards as more effective at delivering a particular outcome than any other technique, method, process, etc. when applied to a particular condition or circumstance" (Frontex RDU, p.19).

Environmental Practice: As identified by the Thai Department of Health, it is: (i) green activities such as recycling waste and increasing green area; and (ii) green strategies (including communication, leadership, cost effectiveness, action orientation, and networking) (Punpeng, 2011).

Environmental Performance Indicator: "Measure the progress towards operational goals and objectives and focus on the efficiencies of the system being measured" (Schuh and Thompson, 2002, p.191 as cited by Mercer, 2006, p. 274).

Key Performance Indicator(s): "KPIs represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization" (Parmenter, 2010, p.4).

4.2 Research Boundary and Key Study Areas

(i) Research Boundary

As mentioned in Chapter 2, the boundaries of both green logistics (GL) and green supply chains (GSC) sometimes overlap. This results in ineffectively observing their adoption process and measuring the performance. Later in Chapter 3, section 3-2, the research scope narrows to focus on internal logistics, from purchasing resources to waste disposal. This research boundary can be developed as presented in Figure 4-1.

(**Note** that there are many more units operating in hospitals than this diagram shows).

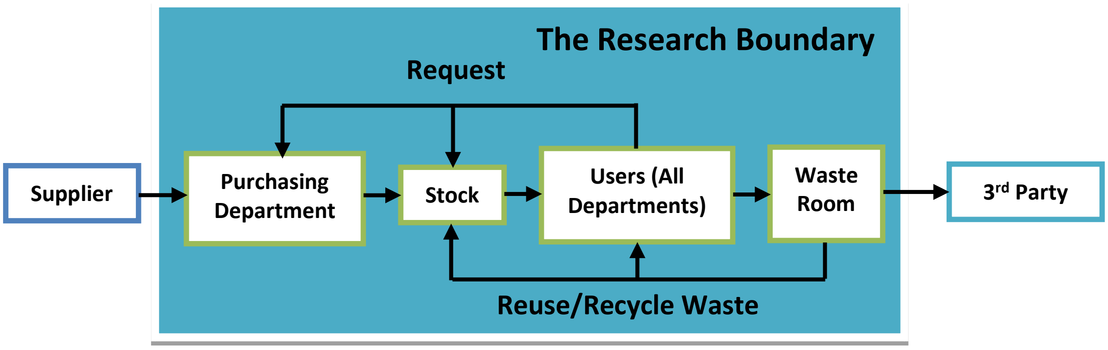


Figure 4-1: The research boundary.
Source: Author.

It is acknowledged that the operations of third parties such as suppliers and waste handlers can impact the environmental performance of hospitals. However, the results of the literature review and the review of current practice (see Chapter 3) indicate that their supply chain linkages are very weak. This is owing to implementing environmental management in Thai hospitals having just started, while GSC and GL adoption are scarcely found. Consequently, the study boundary highlights a public hospital internal logistics.

(ii) Key Study Areas

This section addresses the first research question, which is ***"What are the most important study areas in Thai public hospitals?"***

Chapters 2 and 3 show that to effectively address GL one should embrace the following areas in the study: resources, waste, hospital departments, and all rankings. Accordingly, the answers of this first question are as follows:

Hospital Resources: including medical supply (both single-use and reusable types), medicine, office supply, equipment, food materials, linens, chemical solutions and utilities (electricity, energy and water).

Hospital Waste: including general waste (GW), infectious waste (IW), sharps, hazardous waste (HW) (e.g. expired medicines and used chemical solutions), recyclable waste, reusable waste (including used linen and used medical devices), food waste, and old equipment.

Hospital Logistics Functions: comprised of purchasing, stock management (e.g. pharmacy stock, central sterilisation unit, and office supply stock), distribution (e.g. kitchen), utilization (e.g. ward, clinic and office) and waste management (e.g. laundry, central sterilisation unit, and housekeeping unit).

Note, many departments have operated several logistics functions, and involved several resources used and waste generated.

All Rankings: consist of the Director or Deputy Director, heads of department, officers (including many professions e.g. physician, pharmacist and medical lab technologist), and workmen/women (e.g. housekeeping worker and gardener).

Key Human Factors: include leadership, communication, education, monitoring, evaluation and reward systems, documentation, knowledge and understanding, attitude, behaviour, environmental awareness, compliance and engagement and corporate culture.

4.3 Research Indicators

In order to know which hospital performs GL better, we need to answer the second research question: ***'How should we measure the GL performance of Thai public hospitals, in the areas identified in 1?'*** This research focuses on four areas: environment, social, economic, and logistics. Hence their key indicators were informed by the extant literature and developed as follows.

<u>Environmental Indicators</u>

- The reduced amounts of resources used
- The reduced amounts of waste generated
- The increased volume of green resource
- The reduction of other environmental impacts, e.g. carbon dioxide

<u>Financial Indicators</u>

- Increased cost reduction/improved revenue or overall financial status

<u>Social Indicators</u>

- The levels of legislation/regulation compliance
- Leadership, support, and high engagement of entire organization
- Sufficient education, communication and monitoring
- Good documentation
- Good attitude, awareness, behaviour and understanding
- Sustainable sufficiency culture and good community relationship

<u>Logistics Indicators</u>

- Fast logistical movement: resource, data, and finance
- Small stock volume (high turnover rate with few out of date items)

The researcher has considered that the background environmental knowledge and upbringing of hospital personnel are closely related to personal awareness and behavior and, this impacts on hospital environmental performance. However these issues are outside the research scope, hence they received less concern (see the research indicators in Appendix 5).

4.4 Data Collection Approaches

Data was collected from both primary and secondary sources. The secondary data review supported the investigation of research questions 1 and 2. Primary data was collected to answer the third, fourth and fifth research questions, which relate to: (i) the hospitals that perform best on each measure; (ii) best practice; and (iii) barriers to the adoption, respectively. These three research questions can be addressed by using data from primary and secondary sources.

The question here is *'What research tool(s) can effectively observe hospital GL, when this area is likely understudied?* Chapter 2 has recommended using mixed methods in case study field research, which effectively explore the GL adoption (e.g. Voss et al., 2002, Ubeda et al., 2011). Such methods include documentation, interview, and observation that will be presented below.

4.4.1 Documentation Approach

The documents contain rich information of both texts and statistics. Statistical data can provide very strong evidence to identify the best GL performance. For example, the effectiveness of paper reduction policies is measured by the volume of paper usage. Understanding documents can reduce time in the organizational visit (Yin, 2009). Below are key sources of information that were requested from hospital personnel, in order to answer the research questions.

Key documents from 2010 to 2014 were requested, because: (i) the MOPH formally promoted the sustainable development policy in 2010 (Punpeng, 2011); and (ii) collecting several years' data supports observing the trends of resource and waste.

<u>List of Required Documents</u>

- Hospital annual reports/financial reports (year 2010-2013): provides hospital background, such as number of patients, number of employees, main hospital activities, organizational charts, and the volumes of resource used and waste generated.

- Hospital policy, and manuals/guidelines such as environmental policy, purchasing regulations and waste handling guidelines
- Indicators to measure environmental performance, and outcomes
- Hospital floor plan or map
- Other documents relating to environmental practices, such as research, brochures, and PowerPoint presentations

The hospital personnel informed the researcher that "*these documents may not be ready to be collected; the researcher should inform the hospital earlier for their preparation. The documents can be separately stored, such as in the administrative department, library, quality control department, environmental department, etc."* Hence, this suggestion was followed.

4.4.2 Interview Approach

(i) Interview Type and Process

Reviewing documentation can only provide basic data, but it cannot answer questions about beliefs, attitudes and behaviour. Each hospital could have a different background, regarding the development of green policies, corporate culture and logistics operations. Hence the *'face-to-face semi-structured in-depth interview'* was the most appropriate. This approach offers freedom to modify questions based upon the particular situation. It provides understanding of the issue under consideration by getting insight into the research questions, facts and opinion (Yin, 2009). Interview is the supplementary method of documentation for identification of best practices.

The interviews were designed to last approximately 45-60 minutes or less, since the research concerned the busy operation of the hospital. Each interview should be recorded and noted, for further revision. This recorded data can then be decoded and transcribed right after the interviews, to ensure that observations and insights during the interview process are completely reflected in the analysis (Hartley, 2004). There are many factors that can prohibit people from being completely truthful in interviews e.g. maintaining the hospital's reputation or fear of being disrespectful to senior people. In this case direct observation and triangulation between interviews, observations and documentation can be useful.

(ii) Selection of Interviewees

Because of the research interests of getting data from all rankings and many departments as mentioned, interviewees should be selected as indicated in Table 4-1. For instance, the Director or Deputy Director can give an opinion about the overall environmental policy and future direction; while pharmacists can explain how to reduce use of medicine. Unclear issues can be discussed and clarified by the Director or the Environmental Team in the final meeting.

Table 4-1: List of Interviewees.

Activity	Explanation	Interviewee/Department
(i) Administrative level	Environmental policy, strategy, perception, process, monitoring, etc.	- Hospital Director - Deputy Director in Administration - Environmental Team
(ii) Procurement	Purchasing control	- Purchasing Department
(iii) Inventory management	Office supplies	- Administrative Department
	Pharmaceuticals	- Pharmacy Department
	Chemical solutions and medical supplies	- Laboratory
	Medical supplies and equipment	- Nursing Station/Ward/Clinic
	Foods materials	- Kitchen
	Linen	- Laundry
	Reusable medical supply	- Central sterilisation supply
(iv) Waste management	Waste collection, storage , and incineration	- Housekeeping worker

Activity	Explanation	Interviewee/Department
	Old equipment	- Maintenance office
	Recyclable waste	- Recycling Bank
	Waste water	- Plumber/ Env Team
(v) Green practices	Personnel involved with particular green practices	

(iii) Interview Questions

Since GL is a new research area in Thai public hospitals, questions were prepared in advance to support discussion and explore new points (Göçer and Tuna, 2013). Interview questions were developed based on the literature chapters. The questions were polished with the help of the Director, pharmacist and occupational therapist, who were from different public hospitals. Twelve questionnaire forms for particular professions were produced, also the interview form to be filled in with the interviewee's information and note taking (in Appendices 6 and 7, respectively). Below are the summary interview questions, which are probed with sub-questions along with the respondent's discussions (Göçer and Tuna, 2013).

[A] Respondent Background

1) How long have you been working in this hospital?
2) Please briefly explain your working responsibilities.

[B] Hospital Environmental Programme

1) What is your hospital environmental policy (practice)?
2) How were these policies developed and communicated?
3) What were the drivers for the adoption?
4) What were the barriers to the adoption? And how did you overcome these barriers?
5) Please give the score for reducing resource, sorting waste, and eco-awareness (and behaviour) of your hospital (where 1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent), and give the reason.

6) Please assess your hospital's eco-management over the next 5-10 years, and give suggestions for further development of the green programme?

Note: Questions 7 to 9 are for the Director and Environment Team

7) In the past five years, what have been the trends in the levels of patients?
8) What is the environmental indicator(s)? And how often does the team review/monitor the performance?
9) Please assess the possibility of addressing green logistics (GL) and green supply chain (GSC) in your hospital.

[C] <u>Logistics Operations - Resources</u>

1) What are the main categories of resource used in your department?
2) In the past five years, what have been the trends of such resource use?
3) How do you know the current level of stock and set volumes of purchase/request?
4) What are the criteria to select products?
5) Please explain the process regarding purchasing/requesting, receiving and storing, distributing and using resource(s).
6) Have you faced stock problems like shortage or out of date or damage or long lead time?

Note: Questions (7) and (8) are for these departments: pharmacy, laboratory and central sterilisation unit.

7) What are the turnover rates of medicines and medical supplies?
8) What is your view of reducing the cost of medicines/medical supplies by 10%, and meeting 1-2 months turnover rate, according to the MOPH guidance?

[D] <u>Logistics Operations - Waste</u>

1) What are the main categories of waste?
2) What are the disposal methods of each category of waste?
3) How does the hospital collect and manage each category of waste?

4) Over the past five years, what has been the trend in the level of waste in your hospital?

Note: Questions (5) is for the laundry and central sterilisation unit.

5) What are the cleaning processes of medical supplies or linen?

All questions were open ended type to encourage description and explanation (Robson, 2013). In general, each interviewee was encouraged to express their opinion regarding his/her hospital environmental programme, green practice(s) involved, and relevant logistics activity(s). Specific technical terms like green logistics and electronic procurement were explained before asking questions.

4.4.3 Observation Approach

"Observation", according to Yin (2009), appears to be common as a part of a case study research. It is people's perceptions of objective reality related to research conducted (Sachan and Datta, 2005), involving recording behavioural patterns of people, objects and events to obtain information (Malhotra, 2010).

Observations were carried out during the hospital visits to study the ways people use resources and manage waste. It is supported by note taking and photo shooting. Observation also offered a better understanding of such aspects as: (i) sophisticated flows of various hospital logistics functions; (ii) stock management; and (iii) green practices. This approach helped to triangulate data collected by documentation and interview methods; and reduce bias in the study. Likewise, it is the last chance to collect the required data where the interview and documentation cannot.

4.5 Data Analysis Approaches

Generally, raw data do not speak for themselves; the analytical process teases hidden messages out, and analysis products give the bases for interpretation (Robson, 2013). The highest goal of data analysis is identifying **'Who is the best?'**, and understanding **'What factors contribute to success or failure?'** Thus, this section explains the analytical tools, including a diluted form of content analysis, thematic analysis, and cross-case analysis; and processes to achieve this goal.

4.5.1 Content Analysis

Visiting six case hospitals created a large amount of data obtained by documentation, interview and observation methods. These data were stored separately according to the hospital name. Interviews were transcribed and translated into English. The data were handled by *'content analysis'* method, which critically examines the main idea, common themes, etc. of the content rather than giving a mere description (UTEXAS, 2011).

However, this research did not conduct content analysis of the interviews in the classical way. The research did not code the interviews and put them through NVIVO or a similar program. This is owing to the fact that qualitative research data can be effectively managed manually and this basic or diluted form of content analysis was used in this research.

Note: the research will not use any statistics software because the volume of data is insufficient.

These are the processes of conducting content analysis, in related to the developed themes (section 4.2 (ii)) and research indicators (section 4.3).

1. All interview transcripts (in the CD format attached to this thesis) and documentations were reviewed carefully.

2. The data can be grouped according to their themes or sub-themes. These can be sorted by, for example, words, sentences or paragraphs.

3. The selected data can then be analyzed and compared with the criterion, and identified the performance. It can then be entered into the matrix according to major themes: practices, outcomes and barriers.

4.5.2 Thematic Analysis

Before stepping onto identifying best practices, a *'thematic analysis method'* was adopted. Thematic analysis refers to a process of closely inspecting the text to look for, for example, recurrent themes, relationships, marking similar passages with a code for further retrieval (Mills et al., 2010). Although Chapter 1 (sections 1.5-1.6) explained briefly what the key themes are, this section illustrates profoundly how the themes were developed.

<u>Step1 – A preliminary review of current Thai hospital practices</u>

Themes were first developed from a preliminary review of current Thai hospital practices presented in Chapter 3. At the beginning, there were two key themes: environmental practices and logistics operations. Each key theme contains several sub-themes:

- *environmental practices* cover all processes of addressing environmental policies and practices (e.g. reducing paper use); and,

- *logistics operations* covers movements of resources, waste, information, finance and patients; from purchase planning to waste disposal, of key resources such as pharmaceuticals and foods.

<u>Step 2 – Develop Key Study Areas, Indicators, and 12 Questionnaire Forms</u>

Later, this thesis used data from 'step 1' plus literature to develop key study areas, research indicators, and 12 questionnaire forms for interviewees (or each profession e.g. pharmacist and medical technologist).

Step 3 – Pilot Study and Visits to Five Case Hospitals

Visiting 6 case hospitals (one pilot study plus five case hospitals) generates a large amount of data. It can be grouped into key themes, such as research methods, key interview questions, and 13 professions. For example, for the pharmacist, this profession generally links with the medicine stock management and medicine waste. Therefore, the answers to key questions can be analyzed and compared in order to identify best practices, as well as discussing what makes for success or failure.

During this stage, themes can be identified in major categories (see Chapter 5):

(i) Hospital background (factors) directly and indirectly impact on environmental performance, such as growing volumes of patients generally increase difficulty in reducing resource use,

(ii) Physical practices and their adoption outcomes, such as reducing paper and its usage (reams); and reducing medicine and medicine usage (Baht),

(iii) Barriers to the GL adoption, such as low eco-awareness and insufficient allocated budget, and,

(iv) Implementation practices, such as environmental education and Director support.

The examples of content and thematic analyses are in Chapter 5, section 5.1.

4.5.3 Cross–Case Analysis and Entering Data into the Matrix

The sorted data described above can be summarized and entered into the created matrix's cells, as shown in Table 4-2.

Table 4-2: The Format Matrix for Cross–Case Analysis.

Themes	Hospital 1	Hospital 2	Hospital … N
1. Hospital Background			
1.1 Number of Beds			
1.2 Number of Patients			
:			
1.N Background (N)			
2. Environmental Practice			
2.1 Practice (i)			
Outcome (i)			
Barrier (i)			
:			
2.N Practice (N)			
Outcome (N)			
Barrier (N)			

Sometimes, the practice may comprise of further detail. This detail can be summarized and added into the matrix's cell. 'No Data' is entered into the matrix when the required data is unknown, and 'Discuss' is used when it requires further discussion. Along the way through this data entering process, the similarities and differences can be noticed, so the best practice is clear, when comparing degrees of achieving the objectives across cases (Miles and Huberman, 1994, p.190).

Generally, hospitals with different sizes will show various volumes of resource used, waste generated and CO_2 emitted. Thus, to compare their practices' outcomes require standardization, which divided the outcomes by the number of beds. Using beds as units of analysis was chosen because of less fluctuation than other possible choices (e.g., numbers of patients and staffs). Moreover, graphs showing trends of, for example, hospital resources and waste, can be added to support the analysis.

4.6 Identification of Best Practices

This section explains how the data can be analyse, and how this research can identify the best practice. These can answer **the third research question**: **Which Thai public hospitals are performing best on each measure?**

The sequence of analysis was:

Use the quantitative data collected from records to identify the best performing hospitals against established areas of concern.

(i) Use the data from interviews and observation to identify the practices that had been adopted by the best performing hospitals in each area.

(ii) Identify any inconstancies between the observations and the data/information provided by people at different levels in the organisation. (A basic triangulation of best practice observations)

Therefore, the interview data and observation data can be used in a very focused manner to support analysis of best practice, initially identified using documentation and generalized data. This allows a deeper analysis and discussion around best practice principles. The example of data entry and analysis is in Chapter 5, section 5.1.

4.7 Pilot Study, Selecting Case Hospitals and Ethical Concerns

A hospital visit was considered important because it enabled collecting documents, contacting hospital staff to get feedback and observe behaviour, and mapping of resource and waste flows (Bisson et al., 1993). This section presents the selection of case hospitals, the initial hospital contact and visit, paying regard to Thai culture, and ethical concerns.

(i) <u>The Pilot Study</u>

The involvement of participants from the beginning increases chances of getting the complete and correct data, consistent with Robson (2013).

Because of this, piloting a small scale version was conducted at “A” Hospital (district type with 60 beds). This also helped to understand the feasibility of the research as well as to clarify some important areas, consistent with Voss et al. (2002) and Yin (2009). The outcomes of the pilot study was analysed and presented in Chapter 5, together with the other five case hospitals (“B”, “C”, “D”, “E”, and “F”) because the research wanted to compare their practices and performance.

This section also aims to point to the differences of a THP preliminary study and the pilot study, including their purposes, methods undertaken, durations and outcomes. Table 4-3 shows that a preliminary review of current Thai hospital practices focused on the general issues, regarding the environment and logistics, in order to realize key themes and general logistics functions. The outcomes of the THP preliminary study were used to clarify the GL issues in Thai hospitals, to supplement the Literature Review and inform the design of the second study. Therefore, the THP preliminary study was not further analysed in the main data collection and analysis phases. Because of this, it was not presented in this methodology chapter.

The pilot study tested research tools, such as interview questions, indicators, and documentation. It was conducted at “A” Hospital, which offered a good opportunity to discuss issues with all rankings, observing real practices, and collecting several years of statistical data. Because of this, it was able to initially identify practice performance. It found that the research tools, e.g. interview questions and indicators, are effective, thus there is no need for them to be adjusted before their use in the other five case hospitals.

Table 4-3: Differences between THP Preliminary Study and the Pilot Study.

	THP Preliminary Study	The Pilot Study
1. Purpose of study	- Overall green practice and logistics functions	- All key details in green practice and logistics - Test 3 research tools - Test identifying practices
2. Research questions	- 4 Questions - Developed from literature	- 24 Questions or 12 questionnaire forms for each profession - Developed from a review of current Thai hospital practices
3. Research method	- Interview (telephone call) with 9 staff from 7 hospitals (some rankings)	- Hospital visit ("A" Hospital) - Interview with 16 staff (all rankings) - Documentation - Observation
4. Criteria for selection interviewee	- Convenience, and personal contact	- Recommendations given by research coordinator of "A" Hospital
5. Duration	- 1-2 month	- 1 month
6. Outcome	- Key research themes - Hospital logistics diagram (Figure 3-3) - Potential Interviewees for further study	- All key logistics operations - All processes of green practice implementation - Opinions and good practices identified - Ensure that three research tools are effective, no need to change - Contact the other five hospitals by the support of "A" Hospital

(ii) Selection of Case Hospital

When the pilot study was completed, another five hospitals were selected that are labelled “B”, “C”, “D”, “E”, and “F” (see Table 4-4). It uses a ‘selectively sampling strategy’ method, which these hospitals were recommended by the Director of “A”. They were chosen to give coverage of the different hospital types, locations and a range of environmental performance issues and were willing to be a research case. Because of this, there are six hospitals, including “A” Hospital, for the full-scale study. All names of case hospitals and their locations (provinces) remain anonymous.

Table 4-4: List of Case Hospitals.

No	Hospital Name	Hospital Type	Size	Region
1	“A” Hospital	District Hospital	60	Central
2	“B” Hospital	District Hospital	90	North East
3	“C” Hospital	District/City Hospital	150	North East
4	“D” Hospital	District Hospital	30	North
5	“E” Hospital	Central Hospital	528	Central
6	“F” Hospital	District Hospital	40	Central

(iii) Contacting the Hospital

According to the government norm, contacting each case hospital required submitting a pack of formal documents (in Thai) to the hospital Director for approval, including: an introduction letter (from both the University of Bradford and the researcher’s sponsor), information sheet, research proposal, consent form, a list of documents required, and questionnaire forms. Consequently, it gives clear information about the research objective, methods used, potential respondents, visit duration, support needed etc. Before the visit, the hospital was contacted again by telephone to re-confirm the date, time and required documents.

(iv) <u>Hospital Visits, Ethical Concerns and Limitations</u>

The hospital visits took place between December 2013 and June 2014, each visit taking 3-5 days. At the first meeting, the researcher met the Director or Deputy Director to discuss the purpose and scope of research, as well as how the data would be collected and used. Then, the Director introduced staff who could support the research.

The experience from the pilot study at Hospital “A” shows that some respondents will give information as long as: (i) their voices are not recorded; (ii) their operations are not photographed or videotaped; (iii) their names are anonymous; and (iv) the given documents and information are only used for research purposes. Therefore, the participants’ anonymity and confidentiality have been highly respected. At the very beginning of all interviews, respondents were asked for permission to record interviews, collect documents, and take photographs. Getting insufficient data was solved by arranging additional interviews or observations.

The research has some limitations. Firstly, the best practice found in the study may not be the best practice of Thai hospitals because of a limited number of case hospitals. Secondly, if the research were to be done by other researchers having different perspectives and coming from various academic backgrounds, they may use different approaches that produce different outputs.

4.8 Conclusions

To achieve the research aim, five main questions need to be answered, covering key study area, measurement method, best performing hospitals, best practices and barriers to their adoption. The research boundary focuses on four sustainable dimensions of the single hospital operations: (i) environment (many categories of resource and waste); (ii) social; (iii) economic; and (iv) logistics (from purchasing to waste disposal).

‘Mixed methods in case study field research’ was chosen, which increases the chance of understanding the hospital GL. Such methods include collecting hospital documents, interviewing hospital personnel and observing real operations. Statistical data from the documents can principally be used to identify the best adoption outcomes, while interview and observation give descriptive information regarding practice strategy and detailed operations, for example.

The research was firstly piloted at Hospital “A”, to test the feasibility, increase reliability and validity, and to minimize any risk incurred. After that, visits to a minimum of five case hospitals were undertaken. A large amount of data was expected to be available in the case hospitals, which was managed by a ‘content analysis’ approach to conceptualize the core concepts. Then, this managed data was able to be sorted into four themes: hospital background, physical practices and outcomes, barriers, and implementation practices. Later, the sorted data was entered into the developed matrix. At this point, a ‘cross-case analysis’ method was used to identify the best practices, and the success factors or barriers to the adoption.

In conducting research, several issues were of concern, including: ethics, risk, validity, reliability, bias, generalization and accessibility. The researcher needed to be continuously in consultation with Thai hospital personnel to reflect the reality and to minimize possible risks.

Chapter 5: Data Analysis and Discussions

5.1 Introduction to Data Analysis and Discussions

To identify the best Green Logistics (GL) practices, it is necessary to investigate ‘Who is the best?’ and ‘What makes them a success or failure?’ Accordingly, the principal method adopted is cross-case analysis. In addition, it can be addressed by answering the third, fourth and fifth sub-research questions as follows:

3. **Which Thai public hospitals are performing best on each measure?**
4. **What practices are allowing Thai public hospitals to best perform?**
5. **What are the barriers to addressing environmental programmes in Thai public hospitals?**

(i) <u>Structure of Chapter</u>

This chapter is divided into two main parts: (i) hospital visits and the background of six case hospitals (“A”, “B”, “C”, “D”, “E” and “F”); and (ii) the analyses and discussions. The background contains key factors that affect the GL adoption performance, such as the numbers of beds and patients and hospital accreditation. The analyses grouped practices according to key hospital resources and wastes, such as medicine and medical supply, electricity, and infectious waste. Their ordering is based on the importance of medical services, environment, and finance.

The indicators to identify who is the best are shown in Chapter 4 (section 4.3) and Appendix 5; this is the practice that uses the least volume of resource, or generates the least volume of waste or emissions, etc. The formulas to calculate carbon emissions are in Chapter 3 (section 3.5 (ii)).

The analyses were presented in table format. Tables showing and summarizing practice, outcome and barriers are presented in every section. The tables use some contractions: (i) ‘A (60B)’ means “A” Hospital with 60 bed size; (ii) ‘Not Mentioned’ means this information was not stated by respondent(s); (iii) ‘No Data’ means the data was not given or is not shown in the obtained documents; (iv) per bed (174,731 B) refers to cost per bed is 174,731 Baht; and (v) ‘Discuss’ means the issue will be discussed in the discussions.

The above practice was later discussed more deeply to establish what leads to success or failure, referring to the implementation factors. **Such discussions occurred by the table, not separated chapter. It concludes with some recommendations.**

Notes:

- These keywords have quite similar meanings in the views of six case hospitals: environmental practice, green policy and green strategy/measure/activities.
- 1 GBP is equal to approximately 50 Baht.
- The government year starts on 1st October and ends on 30th September.
- The financial data 2012-2013 of “E” Hospital was not given.
- The hospital visits took place during December 2013 – July 2014, thus the collected data mostly focus on 2010-2013 as mentioned.
- A list of people interviewed is in Appendix 8; lists of documents obtained from each case hospital are in Appendix 9; and, all hospital statistical data are in Appendix 10.
- The interview transcripts are in CD format.

(ii) Examples of Content and Thematic Analyses

This section aims to present how the collected data is analysed. It is divided into two sub-sections: (a) analysis of raw data from one source; and (b) analysis of raw data from several sources.

(a) Example Analysis of Raw Data from One Source – Interview

Researcher: I see. So, how is the waste collected, moved and stored?

(Key Theme and Sub-Themes, respectively)

Mr "A.1": Firstly, I would say that we have several types of waste which are: general waste, infectious waste, hazardous waste, recyclable waste, and sharps. The waste is frequently sorted. Every day, maids (housekeeping workers) will collect the waste, and move it by carts to the waste storage rooms. One room is for general waste, and another is for infectious waste. After that, the trucks come to collect this waste twice a week.

Researcher: Does the infectious waste storage room have temperature-controlled system?

Mr "A.1": No. We don't need a temperature-controlled room **(Barriers)**, because the waste is frequently collected. So, we still can control pathogens growing.

Researcher: Who are the hospital's waste collectors?

Mr "A.1": General waste will be collected by the SAO (Subdistrict Administrative Organisation) and this waste is landfilled. Infectious waste will be collected by the PAO (Provincial Administrative Organisation). This PAO collects infectious waste from all hospitals in "N" Province to be burnt. PAO's incinerator is in "A" District – not so far from the hospital.

Researcher: Have you ever visited them, I mean SAO and PAO?

Mr "A.1": Yes, we visited them about 4 or 5 times in the last 10 years **(Good Practice)**. They invited us to check the quality of their waste disposal. The PAO's incinerator is the most advanced in Thailand, having the highest quality of burning. It can control air emissions and ashes.

The above passage presents the interview transcripts regarding the waste management (see also Chapter 5, Table 5-6: Practices on Reducing Infectious Waste and Outcomes).

From reviewing the interview transcript, the questions and answers should reveal that the discussions were about a particular theme (e.g. waste management). They should also investigate other details such as waste collection, movement and storage, in which case **the key theme** would be waste management, and **sub-themes** include waste collection, movement and storage.

While interviewing, the hospital performance should be asked about and evaluated by checking with, for example, Infectious Waste Handling Guideline (see Appendix 4) and the literature. For any practice that does not meet the criterion, it should be added into the **'barrier section'** of the analysis table. It could be "infectious waste is not stored in the temperature controlled room", this is against the regulation (barrier no.5 in Table 5-6). Others that comply with the criterion can be sorted into the 'practice section', "monitors the performance of waste collectors (SAO and PAO)"; a practical example can be seen in Chapter 5 Table 5-6 which is re-produced below as Figure 5-1 (practice no.11 in Table 5-6).

Environmental Practice	A (60 B)
11. Monitor the performance of 3rd parties (or waste handler)	Yes
Current Barrier: - Do not have a temperature controlled room for IW	Yes

Figure 5-1: Practices on reducing infectious waste.
Source: Author.

(b) <u>Example Analysis of Raw Data from Several Sources</u>

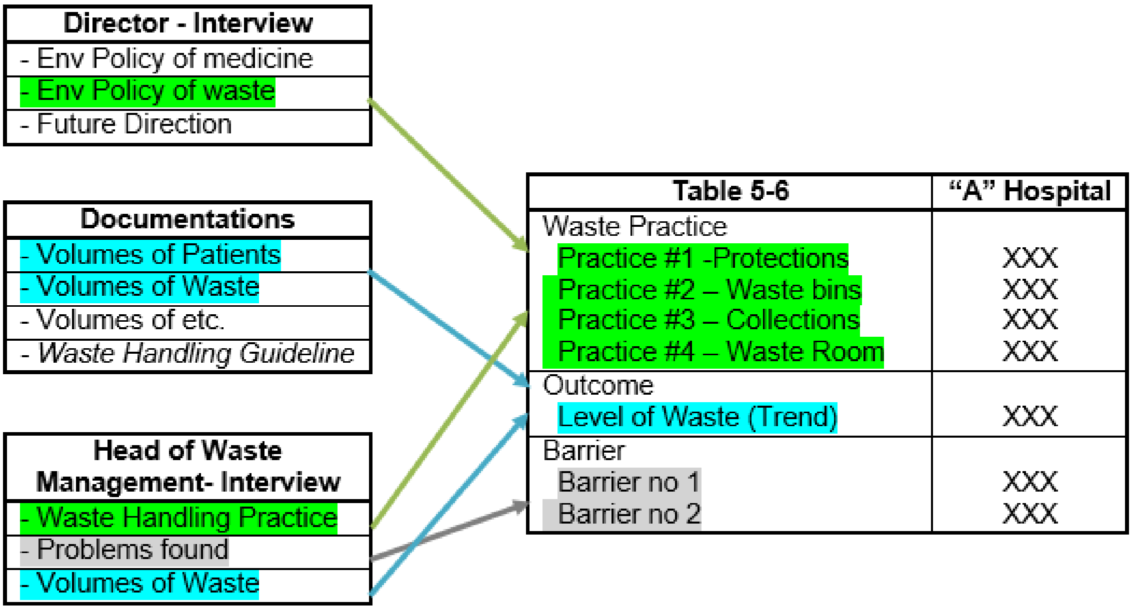


Figure 5-2: Sorting data obtained into the table according to themes.

Source: Author.

Figure 5-2 shows how the collected data can be sorted into key themes. This research adopted three tools (interview, documentation and observation), thus raw data obtained can be firstly sorted into their tools (three boxes on the left). Within a single tool, it provides multiple pieces of information. For instance, interviewing the hospital director gets the data regarding environmental policy (e.g. medicine and waste), and future direction.

Focusing on waste management policies and practices, Figure 5-2 shows that data were obtained from:

(i) Interviews with, for example, hospital director and head of waste management, which they can inform about the practice, performance, and problems. This depends on the questions asked in the meeting, as well as the answers of interviewee,

(ii) Documentation, for example, volumes of waste, trends of which (increasing or decreasing) can be used to identify the success of practices implemented, and,

(iii) Observations of, for example, waste collections, can also be good evidence to confirm the level of practice performance.

All of these data can be sorted into three **themes**: practice, outcome, and barrier, in the table on the right. Since the space in the table is limited, only its **key content** should be derived and entered into the table.

Note that most data presented in Chapter 5 were already manipulated, by looking at key content. The data were later sorted into key themes and sub-themes respectively; outcomes of these analyses are presented in the table format (Tables 5-2 to 5-16), with their descriptions.

(iii) <u>Examples of Data Entry</u>

To give a practical example of data entry and analysis techniques, Figure 5-3, uses data collected during this research project. It clearly shows that several similar practices on medicine have been adopted by case hospitals, including: (i) instructing physicians not to over-prescribe medicines, (ii) exchanging expired items with suppliers; and (iii) operating a returned medicine programme.

However, as far as who is the best practitioner of reducing medicine use, when checking outcomes, only "D" hospital can reduce the volume use of medicine (5.67%) with the lowest cost per bed of 29,588 Baht. As for what makes "D" hospital so successful, the answer lies in two strategies: educating patients to be healthy, and addressing reduction of use policy. In terms of why others failed, the key barrier is physicians do not want to change behaviour in prescribing medicine. Consequently, other public hospitals should address the two strategies like "D" to effectively reduce medicine use and wastage.

Green Practice	"A" Hospital	"B" Hospital	"C" Hospital	"D" Hospital
1. Instruct physicians to not over prescribe medicine	No	Yes	Yes	Yes
2. Exchange expired items with suppliers	Yes	Yes	Yes	Yes
3. Adopt a returned medicine programme	No	Yes	Yes	Yes
Other Strategies				- Educate patients to be healthy - Have reducing use medicine policy
Outcome • A reduction of medicine used	Increased (15.78%), Medicine per bed (174,731 Baht)	Increased (44.38%), Medicine per bed (213,793 Baht)	Increased (58.36%) Medicine per bed (208,154 Baht)	Reduced (5.67%), Medicine per bed (29,588 Baht)
Barrier - Physicians do not want to change behaviour in prescribing medicine	Yes (High & conflict)	Yes (High & conflict)	No	No

Figure 5-3: Example of data entry of medicine.

Source: Author.

5.2 Hospital Visits and the Background of the Six Case Hospitals

5.2.1 Hospital Visits

The fieldwork research was carried out within five days; during office hours (08.30 – 16.30). Case hospitals often provided a coordinator to help select appropriate interviewees, schedule the interview meetings, take a hospital tour and provide documents needed. Pictures of their environmental practices are presented in Table 5-1.

Case hospitals mostly use a centralized administration system in which the Director has the highest authority followed by the board or committee. They oversee core functions (e.g. medical services) and supporting functions (e.g. general administration). Activities like housekeeping, catering and gardening can be outsourced. All cases have an Environmental Team (Env Team) to monitor environmental performance. The Head of Infection Control (IC) Department or Head of Quality Development Centre is often also the head of the Env Team. A paper system is the formal communication within these case hospitals.

From the observations, these case hospitals have very similar patterns of logistical flow, as according to Figure 3-4, Thai public hospital logistics diagram. There are still some small differences in detail. For instance, in medicine practice some hospitals have adopted 'a returned medicine programme' in which the medicine left-over from patients is examined (see section 5.3) so that the waste medicine is more effectively managed than one that does not use this GL strategy. In addition, this can be classified as better life-cycle management.

Note: At "D" Hospital, a coordinator showed how her home and neighbors applied 'SEP' concept (e.g. organic farming, producing EM and organic fertilizer and sorting waste).

Table 5-1: Example Environmental Practices of 6 Case Hospitals.

Hospital	Figure		
A Hospital	EM – Diswashing liquid 	Use a piece of tissue paper a time 	Line graph of electricity cost 
B Hospital	Fertilizer from dried sediment 	Reuse old linen as napkins 	Hospital electricity saving 

Hospital	Figure		
C Hospital	Organic fertilizer 	Cloth bag for chronic patients 	Waste segregation 
D Hospital	Biogas production 	EM-dishwasing liquid 	Organic farming 

Hospital	Figure		
E Hospital	Pull switch light bulb 	Biogas production plant 	Hospital saving energy measures 
F Hospital	Garbage Bank 	FIFO of Medical Supply 	CNG Ambulance 

5.2.2 Hospital Background

(1)-(5) Hospital Size (a number of beds) and Type

Hospital size and type relate to the volumes of patients, resources, waste and employees (see Table 5-2). From the interviews, size and type are also associated with the complexity of organizational structure. For instance, Hospital “E” is the largest (528 beds), has the largest outpatient volume (about 500,000 cases a year) and the most employees (1,529 personnel with 73 physicians). “E” has the most varied specialists, which generate more variety of medical supplies and complex logistics flows than smaller hospitals. Lastly, “E”, with the most complex administrative structure, has higher challenges in increasing commitment, as reported by interviewees.

(6)-(7) Location and Area (square metres)

Hospitals located in the central part of Thailand have a lower risk of medical supply shortage than others because many suppliers are there who can provide fast delivery. Moreover, this area is rich in factories where most workers are foreigners (Cambodian, Laos and Burmese). Foreigners generally receive medical treatment at nearby hospitals (“A”, “E” and “F”) and require twice as many paper documents as Thais.

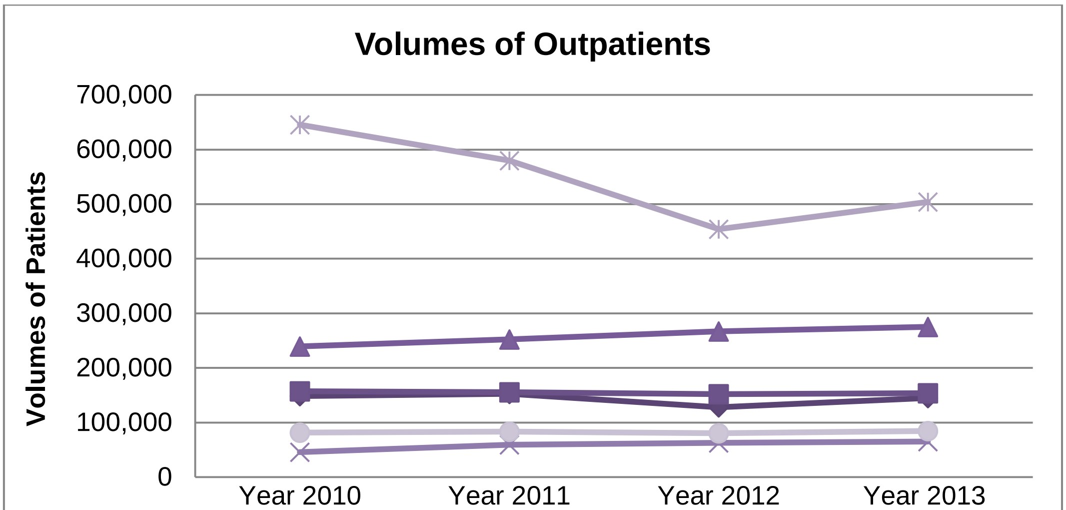
Larger hospitals (in terms of square metres) compared with bed numbers (like “D”), tend to have more free space for green activities (e.g. organic gardening, biogas, and fertilizer). Nonetheless, it seems there is no relationship between location (rural areas and free space) and increasing use of organic food materials. This is because of factors such as lack of interest and no organic supplier.

Table 5-2: Hospital Background.

Hospital Background	A Hospital	B Hospital	C Hospital	D Hospital	E Hospital	F Hospital
1. Hospital Size (Number of Beds)	60 beds (Expanding to 90 beds)	90 beds (Expanding to 204 beds)	150 beds (Expanding to 183 beds)	30 beds	528 beds (Expanding)	40 beds (Downsized from 60 beds)
2. Hospital Type	District Hospital	District Hospital	City Hospital	District Hospital	Central Hospital	District Hospital
3. Number of Employees	162	257	444	161	1,529	153
4. Number of Physicians	7	12	18	3	73	5
5. Number of Wards	2	3	5	1	17	1
6. Hospital Location	Central	North East	North East	North	Central	Central
7. Size of Hospital (m^2)	7,741.44 m^2	19,200 m^2	59,200 m^2	48,000 m^2	104,000 m^2	25,600 m^2
8. Bed Occupation Rate	71.2%	92.43%	82.88%	58.74%	89.00%	57.50%
9. Responsible Population	98,419	No Data	160,599	18,218	139,511	46,647
10. Population per Bed	1,640.32	No Data	1,070.66	607.26	264.23	1,166.18
11. Number of Outpatients	144,846 visits	153,726 cases	275,330 visits	64,970 visits	357,079 visits	84,863 visits
12. Trend of Outpatient Volume	Increased 18.64%	Increased 1.10%	Increased 3.05%	Increased 3.49%	Increased 4.41%	Increased 5.23%
13. Number of Inpatients	12,643 nights	10,392 cases	43,974 nights	No Data	182,783 nights	6,868 nights

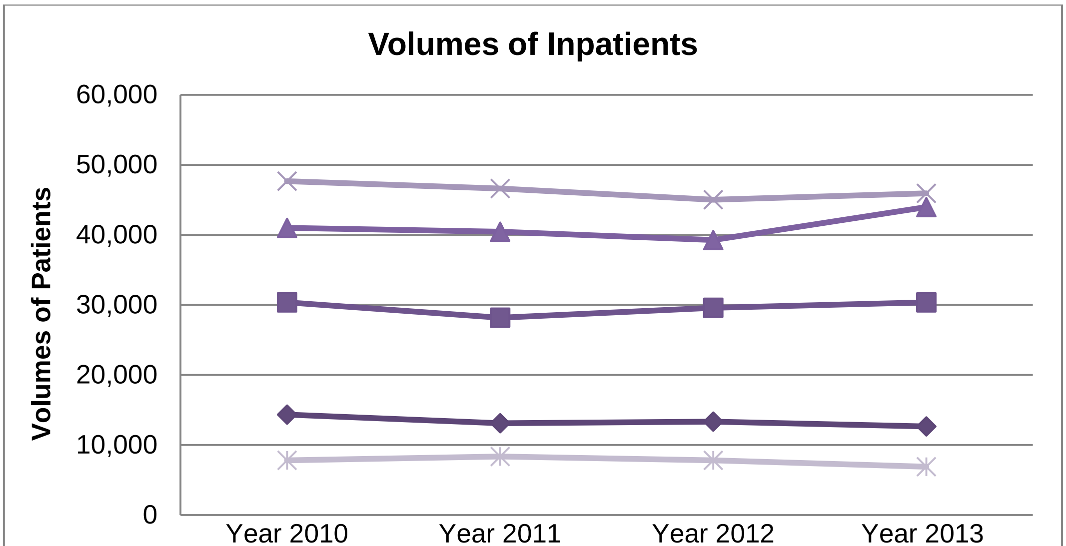
Hospital Background	A Hospital	B Hospital	C Hospital	D Hospital	E Hospital	F Hospital
14. Trend of Inpatient Volume	Increased 20.88%	Increased 2.66%	Increased 12.04%	No Data	Increased 10.78%	Decreased 12.11%
15. Working Experience of Director (until 2014)	13 years	10 years	9 years	7 years	1 year	16 years
16. Level of Hospital Accreditation (HA[4])	HA2 (2012-13)	HA2 (2012-13)	HA2 (2013-14)	HA1 (2012)	HA3 (2013-14)	HA2 (2012-13)
17. GREEN and CLEAN	No	No	Yes	Yes	Yes	No
18. Length of Environmental Management Adoption (until 2014)	2003 (11 years)	1999-2000 (14-15 years)	2003-2004 (about 10 years)	2007(7 years)	2008 (6-7 years)	2007 (7 years)
19. Construction of New Buildings	1 Building	1 Building	2 Buildings	No	1 Building	2 Buildings
20. Financial Situation	Good	Good	Good	Recovering from financial crisis	Good	In crisis

[4] HA has 3 levels; which the highest level gives the greatest government funding based on, for example, hospital size.



	Year 2010	Year 2011	Year 2012	Year 2013
A	148,538	152,617	128,035	144,846
B	157,547	155,561	152,052	153,726
C	239,606	252,638	267,184	275,330
D	45,990	59,495	62,780	64,970
E	645,497	580,113	454,058	503,900
F	81,523	83,344	80,649	84,863

Figure 5-4: Volumes of outpatients.



	Year 2010	Year 2011	Year 2012	Year 2013
A	14,325	13,074	13,310	12,643
B	30,337	28,173	29,577	30,363
C	40,987	40,458	39,247	43,974
E	47,656	46,614	44,994	45,932
F	7,793	8,333	7,814	6,868

Figure 5-5: Volumes of inpatients.

(8)-(10) Bed Occupation Rate and Responsible Population

Bed occupation rate is the number of hospital bed-days divided by the number of available curative care beds (multiplied by 365) (OECD, 2013). The Ministry of Public Health (MOPH) classifies bed occupation rate into three levels: overcrowded (>100%), appropriate (80-100%) and inefficient (<80%). “B”, “C” and “E” have an appropriate bed occupation rate; while “A”, “D” and “F” shows inefficient use of beds. Such lower rates also relate to lower workload, allocated revenues, and efficient resource use (e.g. equipment).

The rate is affected by social and demographic characteristics in the populations, bed management and medical practice (Baillie et al., 1997). Table 5-2 shows “E” Hospital has the lowest population per bed (264.23). But its bed occupation rate is high because this central hospital has received patients from nearby city hospitals and district hospitals. “F” has high responsible population (1,166.18) with a low bed occupation rate, because half of them chose to attend a nearby university hospital.

(11)-(14) Volume of Patients

There are two main types of patients: inpatients and outpatients. The volume of outpatients is mostly measured by numbers of visits and cases; while the volume of inpatients is measured by numbers of nights in hospital and cases. All case hospitals agreed that the patient trend is the most important factor that varies both resource and waste amounts.

In detail, there are two supporting factors, length of medical treatment and medical procedures, as stated by all hospitals. For instance, a delivery case or surgical case often generates more infectious waste (e.g. used linen and used medical devices). Table 5-2 and Figures 5-4 and 5-5 show that only inpatients' volume of “F” Hospital is falling (12.11%), because the government downsized its operation from 60 beds to 40 beds. “A” Hospital shows the greatest increases of outpatients (18.64%) and inpatients (20.88%).

(15) Working Experience of Director

The working experience of the Director links to the green adoption in many ways, such as power, relationships, understanding of subordinates and organizational culture, and communication. For example, an experienced Director may have more power and understanding of his/her hospital than a new Director, which supports the introduction of environmental policy.

(16)-(17) Hospital Accreditation (HA) / GREEN and CLEAN

Being awarded Hospital Accreditation (HA) and/or GREEN and CLEAN logically connect with improved environmental performance. This is because many green activities, such as waste segregation, increasing green areas, and regular maintenance, as well as continuous improvement, are their evaluating criteria. With regard to HA evaluation, it also examines supporting paper documents as well as related departments. Therefore, many resources (e.g. paper, computer supplies, and housework supplies) are used to prepare for this evaluation.

(18) Length of Addressing Environmental Management System (EMS)

According to EMS-ISO14001, the environmental policy (or plan) should be reviewed annually, with major revisions every 3-5 years (INAP, 2010). Consequently, 5-years from adoption will be classified as a mature stage. Table 5-2 shows that all case hospitals are in this stage, hence we can expect the progress and policy revision to fit the organization.

(19) Construction

Only "D" Hospital did not have major construction work during 2011-2013. "A", "B", "C", and "E" Hospitals are expanding their sizes, supplemented by construction of new building(s). "F" has just completed construction of two buildings for Thai Traditional Medicine. The construction, as stated by interviewees, increases use of electricity and water and minimizes green areas. From observations, construction generates noise and air (particles and vapour) pollutions. When the building is opened, all resources and waste volumes become higher on account of more patients, clinical services, and employees.

(20) Financial Situation

Chapter 3 mentioned the 30-Baht scheme that affects hospitals' finances. This was reconfirmed by the Directors of "A", "B", "D" and "F", particularly insufficient budgets and delayed budget allocation. This has led to cutting unnecessary resources, which is also viewed as an environmental strategy. Due to this, positive financial outcomes are noticeable, for example "D" had a profit of 4.5 million Baht in 2013. Only "F" is in crisis, as the decreased revenue is associated with downsizing operations, although "F" has the same amount of expenditure, for example, because of having the same amounts of employees and equipment (maintenance costs).

1st Note: The flood disaster during 2011 destroyed most of the supplies and equipment in "E" Hospital (1st and 2nd floors of all buildings). The new Director (2012) has focused on flood recovery, rather than energy-saving policy.

2nd Note: The government regulation and policy have different meanings. *'Regulation'* is mandatory and requires strict compliance (e.g. infectious waste regulation 2002); although policy is mandated by the government (e.g. 10% cost reduction of medicine), the hospital can explain to the government if it cannot be followed.

5.3 Medicine and Medical Supply

5.3.1 Analysis

(i) Management of Medicine and Medical Supply

This section includes medicines, chemical solutions (mostly used in laboratory), and both single-use and reusable medical devices. In most cases, their stock controllers are as follows:

- The Pharmacy Department mainly controls medicine and single-used medical supplies,
- The Laboratory Department controls chemical solutions, and
- The Central Sterilisation Unit controls and cleans reusable medical devices.

These resources are used in various departments, such as operating rooms, wards and clinics. Users often submit a requisition form to stock and stock prepares supplies for them as well as recording stock on the system. All case hospitals assert that medicines and medical supplies are the most important resources in terms of medication and finance. Minimizing quantities generated and ensuring safe disposal (both solid and liquid waste) relate closely to public health concerns, as mentioned by Mackridge and Marriott (2007), Khunprasert et al. (2007) and Soroslikhit et al. (2008).

(ii) Environmental Practices

There are general practices adopted for effective stock management, including adopting FIFO (first-expired first-out), information systems, and unit dose systems (see Table 5-3). FIFO means items with a shorter lifetime will be used or removed first from stock. Unit dose systems dispense medicine for inpatients according to the meal rather than on a daily basis. Although pharmacists have a greater workload, it gives better control through having fewer medicines left from wards, some of which cannot be used. Pharmacists often set a volume purchase based on historical data, current trend of diseases, season and doctors' habits. For instance, "B", "C" and "D" purchase lower amounts of medicine and medical supplies during the rice harvest because farmers are busier with their farming rather than attending hospital.

Notes: “A”, “B”, “C”, and “E”, which have medicine departments or medical physicians, generally have greater category and volume of medicines than “D” and “F”. Each medicine has a different usage rate that varies the chance of expiry; for instance, malaria medicine has a lower usage rate than paracetamol. Still, the expiry rate of medicine can be reduced by good stock management.

(iii) The MOPH Policy: Reducing Turnover Rate (3 months)

Chapter 3 stated that the MOPH aims to reduce overstock that lowers expiration and financial investment. In terms of GL, reducing the stock size can effectively minimize space, electricity for cooling systems and medicine waste. This waste is hazardous and requires special treatment. Although the policy suggests a 3-month turnover rate, the MOPH requires all hospitals to meet 1-2 months. Consequently, case hospitals frequently monitor stock and purchase, e.g. every 2 months rather than quarterly. The doctors are advised not to over-prescribe medicines or over-order lab tests and are asked for more cooperation. Table 5-3 reveals that “A”, “D”, “E” and “F” can meet the 1-2 months’ goal.

(iv) The MOPH Policy: 10% Cost Reduction

To meet the 10% cost reduction, case hospitals: (i) conduct a joint procurement; (ii) use a unit dose system; (iii) adopt antibiotic smart use (ASU program); (iv) adopt a returned medicine programme; (v) have only one item for each generic name; and (vi) exchange nearly-expired items with suppliers (see Table 5-3). These are perceived as GL practices.

Joint procurement refers to several hospitals in the same region purchasing the same products, which improves negotiating power. But, product prices may be high, since small suppliers that offer cheaper products cannot win the auction. Adopting an ASU programme can reduce drug resistance and costs of expensive antibiotics. To increase cost saving, some single-use medical devices, e.g. plastic oxygen tubes and urine cups, are often sterilized for reuse. This is done while observing Infection Control (IC) procedures.

“B”, “C”, “D” and “F” run returned medicines programmes, particularly tablet medicines of patients with chronic conditions. Medicine can be left over because: (i) patients do not take medicine continuously; (ii) physicians overprescribe medicine; and (iii) patients meet the doctor before the appointment date. The pharmacist only selects tablets in a complete package which has a shelf life, which is later issued to the same patient. Therefore, if a physician prescribes 30 tablets and the patient already has 10 tablets, the pharmacist will dispense only 20 tablets to that patient. For this reason, the hospital can save use of 10 tablets, and give them to another patient.

The hospital has reduced the variety of medicines, resulting in more effective logistics management. Too much variety of medicine occurs because of doctors’ selection, and patients’ rights in accessing different qualities of medicine. For instance, the government officer can get a higher quality of medicine than patients with a 30-Baht right. Lastly, exchanging nearly-expired items or expired items with new ones can minimize drug waste. While the Government Pharmaceutical Organization (GPO) receives expired medicines, private vendors require products with at least 4-6 months lifetime.

(v) <u>Results of Adopting Practices</u>

As shown in Table 5-3 and Figures 5-6 and 5-7, only “D” can minimize medicine usage (5.67%). It also reduced medical supplies (44.42%) and lab tests (12.34%). “D”, according to the Director, firstly informed all employees about the poor financial situation to encourage better cooperation. Later, several practices were addressed, such as advice to patients on weight control, taking more exercise and practising meditation. All physicians at “D” agreed on reducing the volume of chronic medicine prescribed (1 month), and operating a returned medicine programme. This has led to better physical and mental health, which directly reduces hospital visits and the volume use of medicines, according to the research of “D”.

“C” Hospital has increased medicine usage by 58.36%, despite increasing patient numbers only 3-12%. This will be covered in the discussion. Regarding lab tests, it appears that “E” Hospital has the lowest cost of 8,613 Baht per bed.

Table 5-3: Practices of Medicine and Medical Supply and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Inform doctors to not over prescribe medicines or over order lab tests	No	Yes (Ineffective)	Yes (Senior doctors help monitor)	Yes (Doctors often discuss issues)	Not Mentioned	Yes (Ineffective)
2. Explain policy and financial situation to staff	Yes (Low)	Yes (High)	Yes (High)	Yes (Very high)	Not Mentioned	Yes (High)
3. Set purchasing volume based on historical data	Yes	Yes	Yes	Yes	Yes	Yes
4. Adopt FIFO Concept	Yes	Yes	Yes	Yes	Yes	Yes
5. Frequent requisition to reduce overstock/ expiration	Yes (Daily basis for medical supply)	Yes (Weekly basis for medicine)	Yes (Weekly basis for medicine)	Yes (Weekly basis- also purchsing)	Yes (Weekly basis for medical supply)	Yes (Weekly basis for medical supply)
6. Frequently check stock from stock card, computer and manual	Yes (Twice a month for medicines)	Yes (Two weeks for medicines)	Yes (Monthly basis for medicines)	Yes	Yes (Monthly basis for medical supply)	Yes (e.g. twice a month for medicines)
7. Use a unit dose system	Yes	Yes	Yes	No	Yes	Yes

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
(instead of daily dose)						
8. Adopt Antibiotic Smart Use (ASU)	Not Mentioned	Not Mentioned	Yes (2-3 years ago)	Not Mentioned	Not Mentioned	Not Mentioned
9. Adopt a retuned medicine programme	No	Yes (Several years)	Yes (Several years)	Yes (Several years)	No	Yes (Several years)
10. Reduce the variety of medicine (1 type = 1 brand)	No (375 items)	No (About 500 items)	No (400-500 items)	Yes (260 items)	Yes (About 1,000 items)	No
11. Select cheaper items and have joint-purchasing	Yes	Yes	Yes	Yes	Yes (Has shortage)	Yes (both)
12. Exchange nearly-expired or expired item with vendors	Yes	Yes	Yes	Yes	Yes	Yes
13. Use information system for stock management	Yes (HOSxP – cannot process real-time)	Yes (Doctor uses Himpro, but Pharmacist uses DRUG. So, the doctor	Yes (HOSxP – unstable and cannot submit data online)	Yes (Doctor uses HOSxP, but pharmacist uses DRUG)	Yes (Medicine uses HOMC. Medical Supply uses manual system that	No (Only MS Excel)

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
		cannot check the availability of medicines)			brings errors and shortage)	
14. Tag production and expiration dates on cleaned reusable medical supplies	Yes	Yes	Yes	Yes	Yes	Yes
15. Other green practices	“A” (i) Use chemical solution with no carcinogen, which safely discharges to sewage system[5] “B” (i) Pharmacists check rationale for use of medicine with physician and nurse at ward (ii) Reduce stock size of medical supply, which can reduce expiration and re-serialization needed “D” (i) Apply SEP in patient care, and do not view them as customers (ii) Establish 4 policies e.g. prescribe chronic medicine for only 1 month, and outsource lab test (iii) Advise patients and community to: control weight, change eating habit, take more exercise, stop smoking, reduce use of agricultural chemicals, and practice meditation (iv) Reduce medicine used for ‘symptomatic treatment’ (v) Educate patients that taking too much medicine is not good for health (vi) For the same drug, hospital selects giving tablet rather than injection, because injections uses					

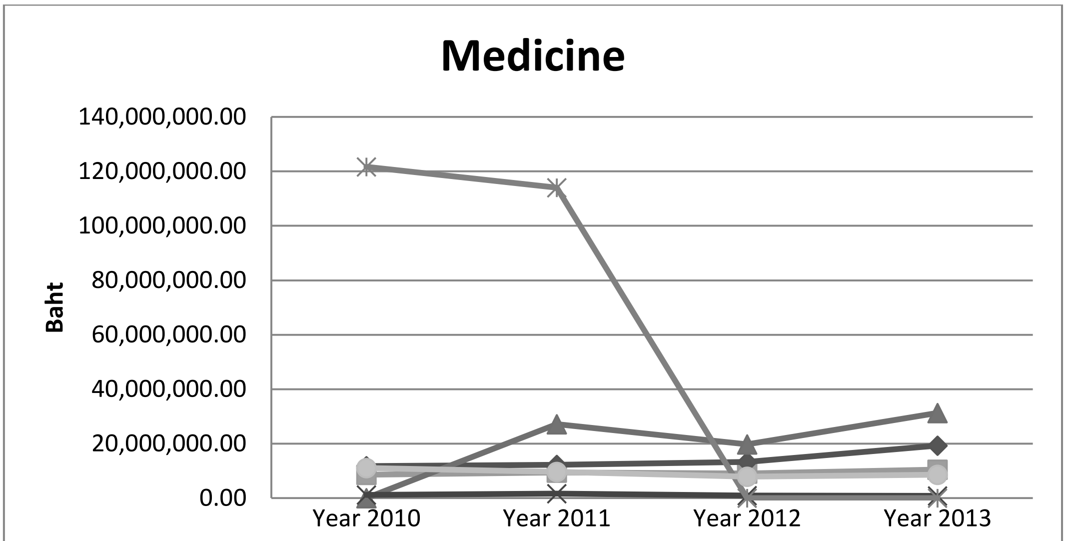
[5] Note: Carcinogen is an agent directly involved in causing cancer. Hence, the chemical solutions that contain carcinogen can affect users’ health, the wastewater treatment system, as well as the environment. There are still some solutions that cannot be found free of carcinogens.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
	more supplies "E" (i) Reuse endotracheal tube 3 times "F" (i) Outsource some lab tests, which reduces investment and maintenance on e.g. equipment (ii) Change technique for electrolyte can save cost					
1st Outcome: Turnover rate is 1-2 month	1.5 Month	3-3.5 Months	3 Months	1 Month	1.5 Month	1.2 Month
Summary	**Success**	**Failure**	**(Discuss)**	**Success**	**Success**	**Success**
2nd Outcome: A volume use of medicines	Increased (15.78%), per bed (174,731 B)	Increased (44.38%), per bed (213,793 B)	Increased (58.36%), per bed (208,154 B)	**Decreased (5.67%), per bed (29,588 B)**	Increased (from interview)	Increased (8.89%), per bed (215,661 B)
Summary	**Failure**	**Failure**	**Failure**	**Success**	**Failure**	**Failure**
3rd Outcome: A volume of returned medicine per year	No Practice	2011: 133,488 B, 2012: No Data, 2013: 123,668 B	More than 100,000 Baht a year (from interview)	About **200,000** Baht a year (from interview)	No Practice	Year 2011: 33,210 B Year 2012: 34,919 B Year 2013: 73,622 B

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Summary	**No Practice**	**(Discuss)**	**Success**	**Success**	**(Discuss)**	**Success**
4th Outcome: A volume use of medical supply	Increased (14.48%), per bed (52,649 B)	Increased (47.54%), per bed (40,343 B)	Increased (21.99%), per bed (131,742 B)	**Decreased (44.42%), per bed (16,411 B)**	Increased (from interview)	Decreased (44.21%), per bed (27,324 B)
Summary	**Failure**	**Failure**	**Failure**	**1st Success**	**Failure**	**2nd Success**
5th Outcome: An amount of lab test (cost)	No Data	Decreased (23.39%), per bed (25,763 B)	No Data	Decreased (12.34%), per bed (29,730 B)	**Decreased (48.96%), per bed (8,613 Bt) [data yr 2011]**	Increased (6.90%), per bed (10,332 B)
Summary:	**No Data**	**Success (2nd)**	**No Data**	**Success (3rd)**	**Success (1st)**	**Failure**
Current Barrier: - Physicians do not change habits in using resources	Yes (High/Conflict)	Yes (High/Conflict)	No	No	No Data	Yes (High/Conflict)
- Increasing NCDs (non-communicable disease) e.g. diabetes and hypertension	Yes	Yes	Yes	Yes	Yes	Yes

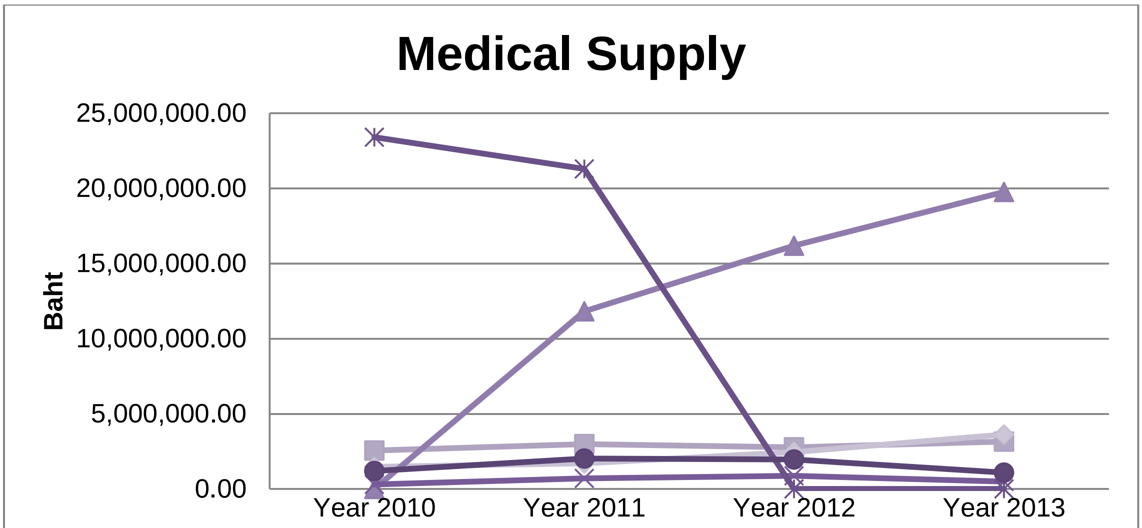
Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
- Increasing operations, specialists and patients	Yes	Yes	Yes (High)	No	Yes (High)	No
- Patients ask for more medicines	Yes	Yes	Yes	Yes	No Data	Yes
- New medical treatment trend needs more lab tests	Yes	Yes	No Data	No Data	Yes (e.g. test blood every hour)	Yes (e.g. more CT scan needed)
- New guideline increases single-use medical devices	Yes (High)	Yes (High)	Yes	Yes	Yes (90% devices)	Yes (user demand)
- The government policy increases hospital access, for minor illness	No Data	No Data	No Data	Yes	Yes	No Data
- High turnover rate of new physician increases unused items they ordered	Yes	No Data	Yes	No	No Data	Yes
- High stock shortage affect the medical treatment	Yes (From the GPO and doctor)	Yes (From the GPO and doctor)	Yes (caused by the GPO)	Yes (caused by the GPO)	Yes (caused by the GPO)	Yes (From the GPO and doctor)

<table>
<tr><th>Environmental Practice</th><th>A (60 B)</th><th>B (90B)</th><th>C (150B)</th><th>D (30B)</th><th>E (528B)</th><th>F (40 B)</th></tr>
<tr><td>- Distributing medical stock to PCU increases workload and stock space needed</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="7">Other Barrier</td><td colspan="6">“A” (i) The Director believes that reducing use of medicine can affect the treatment</td></tr>
<tr><td colspan="6">(ii) Ward often has insufficient resource, solved by borrowing from other hospitals</td></tr>
<tr><td colspan="6">“B” (i) Promote healthy campaign can reduce patient numbers and medicines ordered. But, reducing patients brings lower budget allocation
(ii) Joint purchasing can raise costs; because small-sized suppliers that provided cheaper items and have low capability to supply many hospitals cannot win the auction</td></tr>
<tr><td colspan="6">“C” (i) cannot adopt multiple lab test (within 1 tube) to save resource used
(ii) Being a distribution node of medicines and medical supplies to nearby hospitals, which needs a large stock to prevent shortage
(iii) Provincial Health Office did not fully inform about 10% cost reduction policy</td></tr>
<tr><td colspan="6">“D” (i) The returned medicines are usually found to be expired or in a poor condition</td></tr>
<tr><td colspan="6">“F” (i) Redundant ordering of lab tests because of poor information system
(ii) Drug stock has insufficient space</td></tr>
</table>



	Year 2010	Year 2011	Year 2012	Year 2013
A	8,593,101.97	9,427,086.37	9,055,277.51	10,483,857.33
B	11,801,380.89	12,292,440.81	13,326,704.03	19,241,330.33
C	0	27,163,787.42	19,717,128.10	31,223,061.79
D	1,226,028.31	1,617,838.91	940,974.54	887,629.23
E	121,687,457.10	114,092,208.81	0	0
F	11,078,574.27	9,634,563.90	7,922,276.08	8,626,425.15

Figure 5-6: Expenditure graphs of medicine.



	Year 2010	Year 2011	Year 2012	Year 2013
A	2,561,727.49	2,979,360.02	2,767,523.96	3,158,908.86
B	1,472,713.40	1,709,511.22	2,460,953.26	3,630,864.33
C	0	11,816,202.29	16,198,543.44	19,761,303.18
D	311,246.73	714,059.32	885,755.12	492,327.90
E	23,409,940.62	21,304,781.72	0	0
F	1,198,027.93	2,021,880.97	1,958,965.39	1,092,946.44

Figure 5-7: Expenditure graphs of medical supply.

5.3.2 Discussion

(i) <u>Success Factors of “D” Hospital</u>

Note: Most data in this section are from interviewing the Director, and the GREEN and CLEAN report (in the form of a presentation).

<u>Start from Poor Financial Situation</u>

“D” Hospital, having 30 beds, can provide only basic treatments with a few surgical operations. This leads to the lower use of specific medicines and medical supplies than larger hospitals. Despite increasing volumes of patients (3.49%), volumes of medicines and medical supplies have been reduced by 5.67% and 44.42% respectively. This reflects the successful policy.

The reason for the increasing number of patients is that people from nearby districts thought that transportation to “D” Hospital was better than travelling to their district hospitals. In the past, the 30 Baht scheme rendered “D” unable to pay 2-3 months’ salaries to its personnel, as well as to pharmaceutical suppliers. For this reason, the shortage of medicines was unavoidable. Poor finance has become the greatest motivation that increases engagement with policy. It is particularly in reducing medicine policy that this resource accounts for 60% of the total supply budget, as confirmed by the Director and Head of Pharmacy.

<u>The Study of Sufficiency Economy Philosophy (SEP)</u>

Because of the poor financial situation, the Director thought about reducing resources used, which necessitates addressing ‘reducing patient demand for medical care’. To do this, he asked himself how he could achieve sustainable healthcare, which would help the hospital to survive in the long term.

At that time, he studied the SEP concept which is grounded by Buddhist Principles and the Biological Way concept. SEP guides us to live with existing resources and use them wisely. For instance, reducing use of medicine reduces chemical substances in our body, and using EM replaces many chemical products and uses fruit waste effectively. This radically changed the Director’s attitude to one that views the hospital’s medical service as ‘medical care’, and views patients as world mate not the customer. In consequence, the hospital is responsible in promoting a healthy lifestyle by giving education to patients and the community; rather than only providing medical treatment and prescribing medicines.

The Applications of Sufficiency Economy Philosophy (SEP)

The SEP focuses on increasing participation in administration, promoting sustainable health of both employees and community, and environmentally-friendly use of resources. Four key measures were established: (i) outsourcing lab test services; (ii) prescribing medicine for one month; (iii) dispensing chronic medicines for only two weeks at a time when requiring more than two items; and (iv) quarterly evaluation of hospital finance. The SEP and four measures have been adopted since 2006, and led to a reduction of medicine use by 9.8% in that year. One member of the Team mentioned that “D” has a lower resource use (both for office and medical resources) than the nearby district hospitals.

In the interview meeting, the Director of “D” stated that:

> *“Only 5% of illness is remedied by a doctor like me; but the remaining 95% must be treated by the patient. For that reason, adjusting patient behaviour in consuming foods, exercising, working, smoking and sleeping pattern is very necessary. … And if we have time, I also teach both patients and our staffs breathing. Practicing meditation to make us calm down is really effective in reducing blood pressure in high blood pressure patients; and changing eating habits to reduce diabetes.”*

“D” conducted the research, revealed that patients can better control their blood pressure when praying and practising meditation, which was from 66.10% in 2010, to 83.75% in 2011. These practices also reduce pain experience by patients and conflict in the organization, as stated by the Director.

(ii) **Why did other case hospitals fail to reduce medicine and medical supply?**

Many barriers to reducing medicine and medical supply use were found such as:

- Hospital employees had never been informed about the financial situation, and were rarely asked for cooperation,
- Open discussions to solve this problem were not organized,
- Hospitals had improved patient screening systems, which found more chronic diseases,
- Many patients thought that using more medicine was good for health and meant they were receiving proper medication, therefore they often asked for more medicine and medical supplies, and,
- The new medical practice requires more lab tests to confirm the diagnosis as well as to protect the physicians.

The most important barrier is hospital personnel perception. They basically view medicine and medical supply as the most important resources, and believe reductions might affect medical treatment. Presently, there are neither strong guidelines nor evidence to confirm the benefit of reducing medicines, or suggestions of how to affect it.

On top of that, physicians do not want to change their habits in prescribing medicines, using medical supplies, and ordering lab tests (“A”, “B” and “F” Hospitals). The Director cannot really put pressure on physicians, because of working in the same position and the scant workforce. Instead, the hospital has to provide all resources needed to retain physicians. Subsequently, physicians can order different medicine that brings too much variety of medicines, unused medicine and expiration. Lastly about 10% cost reduction, one pharmacist of “B” claimed that the MOPH does not clarify what is the base year.

Another barrier is the increase of primary care units (PCU), for which hospitals have to purchase and distribute medicine and medical supplies. Still, additional interviewing found that these resources distributed are excluded from the hospital financial report. Therefore, it has not affected the overall volumes.

(iii) <u>Should the hospital meet 1-2 months turnover rate</u>?

Such physician behaviour also hinders achieving 1-2 month turnover rate policy. Previously, medicine and medical supplies were often purchased every 4-6 months (2-3 times/year). The policy requires purchasing every 1-2 months, while physicians prescribe long-term medicine for 4-5 months. In consequence, an imbalance between stocking and using rates emerged. This led to resource shortage and internal conflicts among departments (physicians, pharmacy, laboratory, and central sterilisation unit).

“C” maintains a 3-month turnover rate. It has to stock a larger volume to prevent shortages because of being a node for distributing medical resources to nearby hospitals. Senior physicians help control use of medicine, and all professions often solve problems together, hence “C” rarely faces conflict and shortage problems.

The question is *‘should the MOPH and all public hospitals aim for a 3-month turnover rate, and solve this problem together?’*

(iv) <u>Shortage of Medicine and Medical Supply</u>

This shortage is mostly affected by: (i) late payment owing to poor finance; and (ii) late product delivery and halting of production by the Government Pharmaceutical Organization (GPO). According to the MOPH (2012), all public hospitals have to purchase medicine from the GPO at the mandated volume (see Chapter 3, section 3.2). The question for the GPO is *‘How can the productions and services be improved?’* To solve this problem, case hospitals have to purchase resources from private suppliers, borrow from nearby hospitals, postpone patients’ appointments, use interchangeable items, dispense less medicine at a time and ask the patient to collect the rest later. And thus, this long lead time can affect patients and medication.

(v) Ordering Laboratory Tests

Heads of Laboratories reported over-ordering of lab tests by doctors. For example, the doctor orders a blood test every hour rather than according to actual need as previously. This raises the use of test tubes around three times. From Table 5-3, "E" (528 beds) shows the lowest cost of lab tests (8,613 Baht/bed) without any outstanding practice adopted. Its stock controller mentioned the following practices: frequent purchasing (1.5 month turnover rate), no/low expiration found, and bulk and joint purchasing. In addition, "E" services lab tests for smaller hospitals; accordingly cost can be shared among many customers. In short, significant cost reduction of medical supply would relate to efficient management of stock, cost and lab test services.

(vi) Returned Medicine Programmes

"B", "C", "D" and "F" have adopted returned medicine programmes. As pointed out by a pharmacist at "C", this programme offers two benefits: *"one – we can check our patients' behaviours in taking medicines and two – we can reduce hospital cost (by reducing use of medicine)."* Another benefit mentioned is increasing safe medicine waste disposal.

"E" has not operated this programme, because it is difficult to ensure the quality of medicine returned. As stated by a pharmacist at "E", most medicines can deteriorate in Thailand's humid weather, and due to poor storage. Checking the quality of medicines is a complicated process that increases workload and time. The greater volumes of medicine returned may signal over-prescribing medicine or poor medicine-taking behaviour. If this idea is correct, prescribing of medicines in "B", "C", "D" and "F" would be of doubtful efficacy.

1st Note: The Deputy Director of "C" stated that reducing medicine may not be beneficial. One pharmacist said that:

"Reducing medicine is good because there are a lot of irrational uses of medicine found in Thai hospitals. But, it cannot be concluded that reducing use of medicine is good for every case, because doctors may already follow the good guidelines."

2nd Note: For cost effective purposes, hospitals have reused single-use medical devices, but this can expose patients and staff to unnecessary risk. This issue will be deeply discussed later.

(vii) Single Use VS Multiple Use Medical Devices

For cost effective purposes, all case hospitals reuse single-use medical devices, including plastic types (e.g. oxygen tubes and urine cups). The devices that contain plastic should not be re-sterilized and re-used, because their condition will deteriorate by use of heat. Despite the fact that the hospitals have acknowledged these Infection Control Guidelines, limited budgets have led to continuing such practices. Hence, the government should provide more monitoring and allocate more budget to purchasing these required single-use devices, or the usage of multiple-use devices should be promoted.

Increasing use of single-use devices was found (e.g. small medical care sets), which is strongly mandated by the MOPH. This is because the MOPH considers increasing safety and hygiene. It also increases convenience for the hospital that does not clean it after use. But this directly generates greater purchasing expenditure, and increases infectious waste volume and its handling cost. In addition, its manufacturing increases use of resources. All Heads of Sterilisation Units have argued that much metal ware and glassware can be reused, thus multiple-use devices should be reconsidered. And, there is another issue to be examined: 'For the multiple used items, no clear guideline has informed how many times that these devices can be reused'.

Concluding Remarks

New policies should be embedded, such as prescribing chronic medicines for only one month and increasing follow-up processes, having returned medicine programmes with close monitoring, and having good communication among staff with continual evaluation systems. In addition, the hospital should establish a sustainable health system that integrates patients, staff and the community. Education is needed such as exercising, diet and practising meditation.

5.4 Utility – Electricity

This part of the study relates to the hospital financial report, which separately shows three elements of utilities: electricity, energy and water. The electricity costs of the six case hospitals are comparable, as a unit cost was set by the Electricity Authority.

5.4.1 Analysis

(i) <u>Practices for Saving Electricity</u>

As mentioned by "E", air conditioning systems account for the greatest proportion (60%) of total electricity usage. In addition, the trend in electricity usage has been increasing in all case hospitals. Thus, many interesting practices have been addressed as shown in Table 5-4.

"B", "D", "E" and "F" established specific energy-saving teams/persons to monitor electricity usage, while this area is handled by the Environmental Team in "A" and "C". They are responsible for announcing policy/measures, reporting cost in the meeting, and encourage others to save electricity. The most common practice is turning-off all electric devices when not in use.

All case hospitals established an opening hour for high-electricity-consuming devices like air conditioners (e.g. 9.30-11.00 and 13.00-16.00) and electric kettles (e.g. 10.00 am and 2 pm). Several saving-energy appliances (such as light bulbs and refrigerators) were selected. Walking surveys are often conducted to observe and correct user behaviour, as well as to turn off all remaining appliances. In the interview meetings with the Director or Deputy Director of "B", "C" and "D", they did not turn on the light and air conditioner. This is because natural light is sufficient during daytime, and this can save electricity, in line with the hospital policy.

Evidently, "E" has addressed the widest range of practices. Pull-switch lighting over every working desk and patient's bed was installed. In the wards that have a number of beds, patients can turn-off their overhead light when they need to sleep. Consequently, this supports both electricity saving and patients' health.

The engineer of “E” asserted that setting the air conditioner to 26-27C with the highest fan speed uses lower electricity than 25C with the low or medium fan speed. And, users should not sit under the air conditioner. This provides the same comfortable atmosphere, and cuts more cost. “C”, “E” and “F” installed electricity meters in the key buildings. It is likely that only “E”, which has proficient technicians, has regularly analysed and reported electricity consumed for each building.

(ii) <u>Outcomes of Addressing Electricity-Saving Policy</u>

Despite efforts in saving electricity, electricity costs of the five case hospitals (“A”, “B”, “C”, “D” and “F”) are growing at rates of between 22.32% and 42.45% (see Table 5-4 and Figure 5-8). The observations revealed that only employees of “B” and “E” habitually turn off electric devices (e.g. light) during lunch time and after work.

Only “E” has minimized electricity usage in total, which equates to 1,151,474 kilograms of carbon emissions, or reaches to 8.93 million Baht in cost saving. Electricity cost per bed of “E” is 28,357 Baht (data of year 2010). Even if this figure includes energy and water costs, it is still lower than other hospitals for electricity alone. Additionally, both the Deputy Director and engineer of “E” have claimed that this trend remained the same throughout these 4-5 years. The electricity cost of each practice of “E” was measured and analyzed separately. For example, setting the air conditioner to 26-27C can reduce 218.52 tonCO_2/year or 1.3 million Baht of cost saving. Another example is replacing T8 and T12 fluorescent tubes by T5 type which brought better lighting, longer lifetime and lower waste, and saved 73,376 Baht/year. Therefore, it shows that the electricity management practices in “E” represent best practice.

“C” can represent the second success in saving electricity. This is owing to a low cost per bed of 39,182 Baht, despite the construction of a large new building, service extension and increase of outpatients (3.05%) and inpatients (12.04%).

Table 5-4: Practices in Reducing Electricity and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Solve high electricity use issues in meetings	No (By 3 members of Env Team)	Yes (Has complaint center)	Yes	Yes	Yes (By Energy Saving Team)	Yes (Representative of departments)
2. On-going communication and promoting the policy	No	No	No	Yes (By Env Team)	Yes (e.g. meeting, newsletter)	Yes (By Electricity Team)
3. Continually monitor and report outcomes to remind staff of economic use	Yes (Irregular monitoring, but often review outcomes in the meeting)	Yes (Analysed with last year data, and shown in the meeting	Yes (In annual meeting)	Yes (In the meeting)	Yes (Continual monitor, but discontinuous reporting outcomes)	Yes (Analysed with 5-year data, and report in the meeting)
4. Set an opening time of e.g. air conditioner	Yes	Yes	Yes	Yes	Yes	Yes
5. Medical stock uses automatic temperature-controlled air conditioning	Yes	No	Yes	No Data	No	No Data

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
6. Turn on air conditioner at 25C and close doors and windows firmly	Yes	Yes	Yes	Yes	Yes (Use 26-27C with highest fan speed), **(saved 1.3 million B/yr or 218.52 tonCO_2/year)**	Yes
7. Sufficient monitoring	No (Heads monitor subordinates)	Yes (Done by the Director and volunteers)	No Data	Yes (All staffs help monitor it)	Yes (Staffs monitor each other)	Yes (Heads monitor subordinates)
8. Install meters in high electricity use buildings or construction	No (Cannot install more meter)	No (Cannot install more meter)	Yes	No Data	Yes (Key buildings have meters)	Yes
9. Centralized use of electric devices e.g. kettle and printer	Yes	Yes	Yes (1 kettle for 1 building)	Yes (1 kettle for 10 staffs)	Yes	Yes

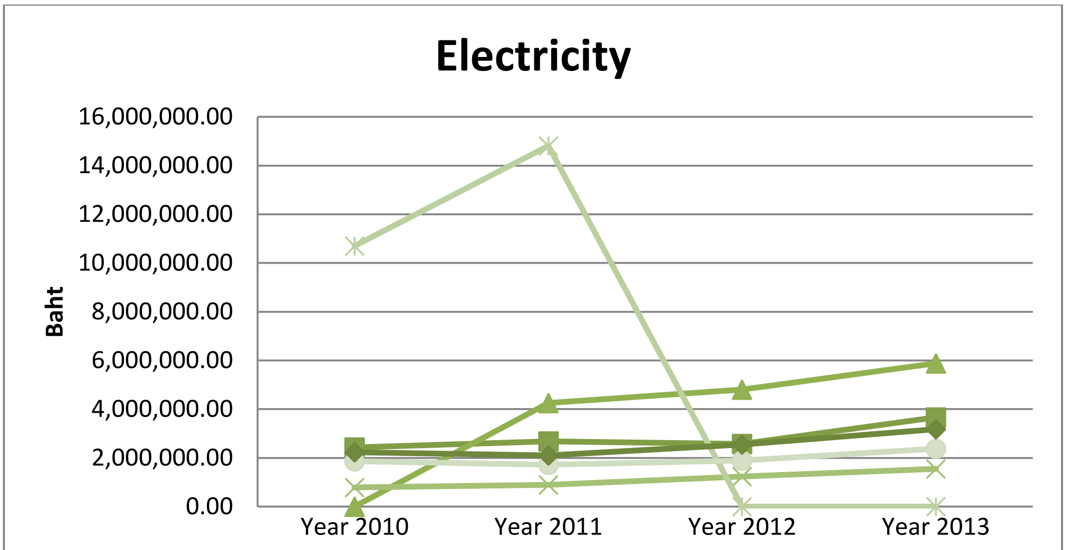
Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
10. Use saving- energy appliances	Yes (Light bulb)	No	Yes (e.g. light bulb)	Yes (e.g. light bulb and air conditioner)	Yes (e.g. steamer and air conditioner)	Yes (e.g. light bulb)
11. Walk upstairs instead of using elevator	No (No elevator)	Yes	Yes	No (No elevator)	Yes	No (No elevator)
12. Security guard turns off remaining electric devices	Yes	Yes	Yes	Yes	No Data	No Data
13. Survey electricity leak	No	No	Yes	Yes	Yes	No
14. Use pull-switch lighting	No	No	Yes	No	Yes **(saved 47,563.97B/yr or 7.75 tonCO$_2$/year)**	No
15. Reduce unnecessary light bulb use	No	Yes	No	No	Yes **(saved 490,316.82 B/yr or 79.96**	No

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
					$tonCO_2$/year)	
16. Dry linen in the sun	No	No	Yes	Yes	Yes	Yes
17. Switch using air conditioners	Yes	Not Mentioned	Yes	Not Mentioned	Yes	Yes
17. Other green practice	"B" (i) Remind staff and patients to turn off electric devices on radio broadcasting, and posters (ii) Promote the campaign every week "C" (i) Use 70% of refrigerator's space "D" (i) Sterilize medical supplies when have sufficient volume "E" (i) Reduce use of air conditioning by increasing partitions in a large room, or using electric fan or natural air, adding more windows (also to get more light), and growing trees (ii) Boil only the water needed (iii) Provide energy saving training annually, and focus on eco-awareness and behaviour (iv) Consider payback period and return on investment when choosing new green technology (v) Have a slogan and reducing energy competitions (vi) Use T5 fluorescent tube instead of T8 and T12 **(saved 73,376.47 B/yr or 11.96 $tonCO_2$/year)** (vii) Centralized control of air conditioning system, and install a timer at air conditioner **(saved 712,393.04 B/yr or 116.17 $tonCO_2$/year)** (viii) Install 'Energy Management System' software **(saved 264,042 B/yr or 4.03 $tonCO_2$/year)**					

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
	(ix) Better control of water pump system **(saved 7,067 B/yr or 1.15 tonCO_2/year)**					
	"F" (i) Use metal sheet roofing to absorb and retain heat (ii) Use a water curtain, fountain and misting fan for heat stress relief (iii) Install solar cells (iv) Coordinated with the university to identify the best practice(s) (v) Reduce time for washing linen from 60 to 45 minutes					
Outcome: 1. A volume use of electricity	Increased (24.58%), cost per bed (52,996 B)	Increased (42.45%), cost per bed (40,667 B)	Increased 22.32%, cost per bed (39,182 B)	Increased (25.90%), cost per bed (51,706 B)	**-Total utility cost of yr 2010 decreased (39.69%), -Electricity and energy reduced 8.93 million Baht -Per bed yr 2011 (28,357B)**	Increased (25.59%), cost per bed (59,390 B)
2. Carbon emissions	No Data	No Data	Increased by 140,213 kWh	Decreased by 5,468 kWh	**Yr 2010, decreased by**	No Data

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
			(10.27%) or 78,660 $kgCO_2/kWh$	(16.36%) or 3,068 $kgCO_2/kWh$	**1,151,474 $kgCO_2/kWh$**	
3. Observation: the Director/Deputy Director turned-off the light and air conditioner in the interview meeting	No	Yes	Yes	Yes	No	No
4. Observation: electric devices are turned-off at lunchtime and after work	No (e.g. computer and light)	Yes	No (e.g. electric fan and light)	No (e.g. light, computer, and air conditioner)	Yes	No (e.g. electric fan)
Summary	**Failure**	**Failure**	**Success (2nd)**	**Failure**	**Success (1st)**	**Failure**
Current Barrier: 1. Construction	Yes	Yes	Yes	No	Yes	Yes
2. Staff consider their convenience (e.g. switch on	Yes	Yes (High)	Yes (Low)	Yes (Observation)	Yes	Yes

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
air-conditioning at lunch time)						
3. Many areas operate 24 hours a day such as a lab	Yes	Yes	Yes	Yes	Yes	Yes
4.Other	No	No	No	-Operating Thai Traditional Medicine -Each desk has a computer	No	No



	Year 2010	Year 2011	Year 2012	Year 2013
B	2,430,488.98	2,675,235.40	2,569,495.55	3,660,205.50
C	0	4,248,027.45	4,804,639.80	5,877,255.00
D	784,219.61	886,565.15	1,232,097.19	1,551,174.25
E (utilities)	10,701,903.03	14,802,281.68	0	0
F	1,863,999.65	1,725,923.40	1,891,454.24	2,375,560.98
A	2,229,086.96	2,103,557.31	2,552,329.50	3,179,763.38

Figure 5-8: Expenditure graph of electricity.

5.4.2 Discussion

(i) Success Factors of "E" Hospital

Although its operational size is being enlarged, "E" can cut electricity costs by up to 40% because of the combined factors discussed below.

Key Learning Point 1

"E" has shown its intention to save energy since 1995 by registering with the Thai Green Building Institute (TGBI). Formerly, the hospital had received a lower budget that affected the service extension. The previous Director, who retired in 2012, thought that saving energy would be one of the solutions. Additionally, the use trend was dramatically increased, which was viewed as excessive.

Even if the hospital learnt from the best saving-energy hospital, namely Vachira Phuket Hospital, the lesson was hardly applied because of insufficient knowledge. For instance, hospital technicians could not use specific software to automatically manage use of electricity in a large building, and the administration could not decide on select the most effective practices (e.g. the selections of biogas or solar cell). In consequence, a consulting company was hired to identify weaknesses and suggest solutions. After that, developing an energy-saving policy was addressed in 2008:

"The hospital proposes to become an excellent model in energy saving, and the hospital will use all types of energy more efficiently and reduce unnecessary usage".

This aim was set in 2010 *"to reduce energy-electricity cost by 10% from the year 2009"*.

The concept "Hardware, Systemware, and Peopleware" was later created and addressed to support energy-saving policy.

Peopleware Concept

Peopleware, particularly raising awareness, was most emphasized by the previous Director. It is viewed as much more sustainable than improving hardware (equipment and infrastructure) or systemware (policy, goal, structure and application). Consequently, energy-saving training was firstly provided to adjust perspective and awareness, for example, at the Energy Conservation Building. This also includes annual training, to update energy-saving practices, and regularly reporting outcomes.

The previous Director was largely perceived as the crucial success factor because of his encouragement, views, energy-saving behaviour. Once he said that: *"If employees do not help the hospital in saving resources, the hospital may not survive"*. He principally adopted a 'leading by example' strategy, such as walking upstairs to the 5th floor instead of using the elevator.

The energy-saving team established comprises representatives from all departments and all rankings. They can share their ideas on saving energy in meetings, and monitor their department's performance.

Systemware and Hardware Concepts

Systemware refers to putting a structure in place that allows people to make evidence-based decisions. This includes having a clear goal, policy, structure and application. The previous Director had restructured the hospital by installing several green technologies/practices, producing energy-saving guidelines and developing an evaluation system. In selecting green technologies, payback period and return on investment were carefully considered, which generated large amounts of both carbon and cost reductions. For instance, the hospital thought about using more renewable energy, for which there are such options as solar cell and biogas. Finally, biogas production was addressed because of offering many benefits: reducing food waste volume, having the shortest payback period, replacing kitchen LPG by 25-30%, and generating EM as liquid fertilizer.

Between 8th October and 21st November 2011, “E” faced the great floods. Up to the present time (3-4 years later), the hospital under the new Director has had to recover from the floods. Energy-saving is carrying on because of well-trained staff. “E” was certified by the ‘ASEAN Energy Award Year 2010’, and has delivered their know-how to the community and many public organizations.

(ii) Barriers to Reducing Electricity Usage

The other five hospitals would like to reduce electricity costs by addressing similar practices to “E”, but their performance is inefficient. The analyses show several barriers: construction, staff overuse of electricity, insufficient monitoring, and increasing use of air conditioning and computer systems. All hospitals cited effects of global warming and the tropical climate which raises electricity consumption through increased use of air conditioning systems. Increasing numbers of patients and services were also mentioned.

The failure of “D” was explained as due to the herbal steam sauna of Thai Traditional Medicine using large amounts of electricity. “A”, “B”, “C”, and “E” did not mention this barrier, despite operating the sauna. Hence, the relationship between sauna and increasing electricity usage is inconclusive. Other reasons given by “D” are replacing LPG for an electric steamer and providing a computer for every working desk. It is believed that sharing use of a computer can be the solution.

Regarding “B” Hospital, its electricity saving is the poorest. “B” cannot separate electricity metering of construction work and the hospital, consistent with the Provincial Electricity Authority. In consequence, this has driven higher electricity costs than actual hospital usage. “A” faces the same problem as “B”. If these two hospitals had proficient technicians, like “E”, installing more meters for measuring electricity use in every key building would be feasible.

Concluding Remarks

The HW/SW/PW concept is a very important strategy for success, which all public hospitals should address. Giving energy-saving knowledge to all staff is really needed to properly address a sustainable culture. Reducing use of air conditioning is the most recommended, including using 26-27C with the highest fan speed, using more electric fans or natural air and growing more trees to lower the temperature. The hospital can gain good benefits from using pull-switch lighting and energy-saving appliances and installing meters in key buildings.

5.5 Utility – Energy

5.5.1 Analysis

(i) General Information

The types of energy used by case hospitals include diesel fuel, petrol, liquefied petroleum gas (LPG), liquefied natural gas (LNG that is used with NGV vehicles) and biogas. Their costs are often combined as shown in the financial report. But, "C", "D" and "E" have each produced another report for the GREEN and CLEAN programme, showing many details such as the volume of each type of energy usage. Calculation of carbon emissions here has adopted a formula previously shown in Chapter 3.

According to the Petroleum Authority of Thailand (PTT, 2015), retail prices of fuels are as follows: petrol 95 (35.66 Baht/litre), petrol 91 (28.68 Baht/litre), petrol E20 (27.28 Baht/litre), petrol E85 (23.38 Baht/litre), diesel (25.59), and NGV (13.00 Baht/kilogramme).

(ii) Energy Saving Practices

As presented in Table 5-5, there are four key practices for saving energy:

- Producing biogas from food waste or animal manure,
- Use LPG or LNG e.g. with boilers and vehicles,
- Using a hospital car pool, and,
- Riding bicycles (in the hospital area).

There are other practices, such as "E" reuses steam from the boiler in the laundry, central sterilisation supply, kitchen and water production, and adopting driving speeds of less than 90km/h to save energy.

(iii) Practices' Outcomes

The biogas production from food waste of "E" Hospital can replace 25% of the kitchen's LPG requirement. This reduced 455.4 tons of CO_2 a year or saved 408,662 Baht, as well as offering effective food waste management. "D" produces biogas from manure which replaces half of the kitchen LPG (10 tanks), equating to 444 kgCO_2/year (1 tank of LPG has 15 kg). “D” has decreased use of diesel fuels in vehicles and boilers, giving a total carbon reduction of 2.2 tons/year.

Also, a car pool has been adopted to transport employees and their children between “D” and the city centre. Accordingly, each employee can save up to 1,500 – 2,000 Baht a month. A car pool at “C” transports at least three personnel to the same destination. “C” argues that it is one of factors that reduced fossil fuel use by 574 litres, or 1,538.32 kgCO_2/year. The key practice adopted by “F” is using NGV ambulances. These vehicles generate lower environmental impacts than diesel fuel (4,788 kgCO_2/year) and are more cost-effective (380,000 Baht/year).

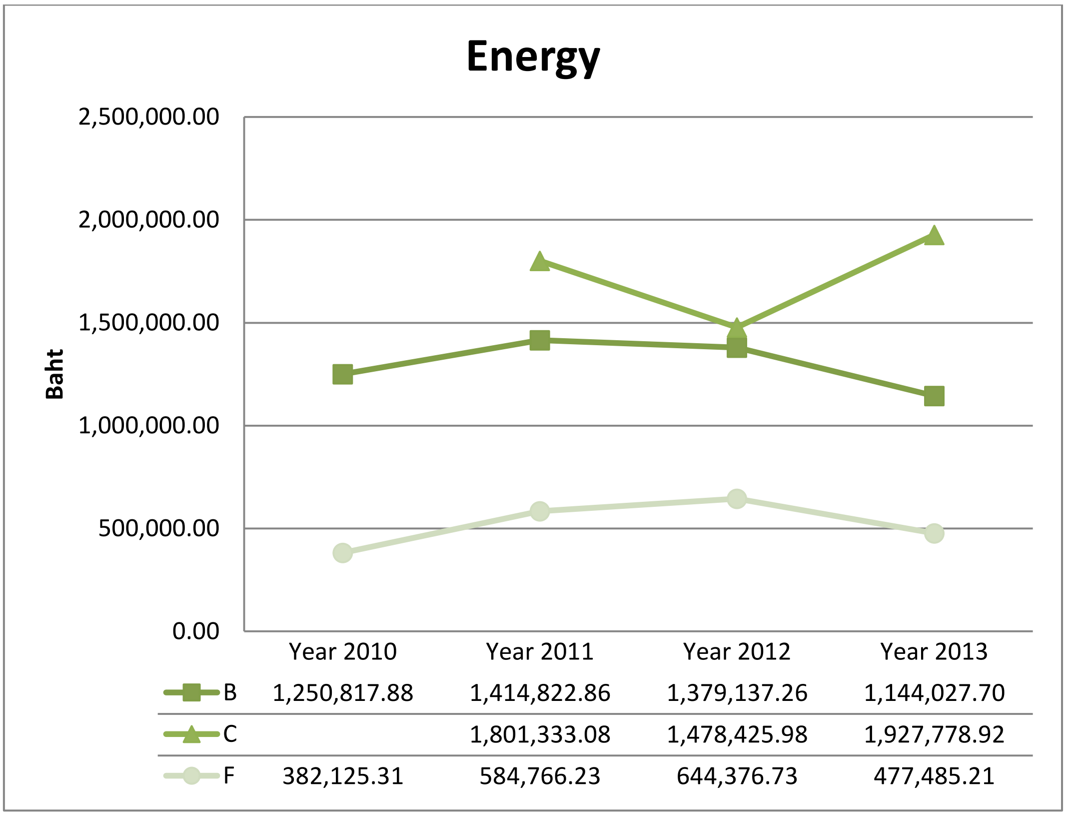
The total outcome was that “B” and “F” decreased their energy costs during 2012-2013 by 17.05% (or 12,711 Baht per bed) and 25.90% (or 11,937 Baht per bed) respectively. Since “A”, “D” and “E” did not separately report energy expenditures, their total costs are not known.

In conclusion, the best practitioner(s) of energy saving are as follows: (i) biogas production are “D” and “E”; (ii) LPG are “C”, “D” and “E”; (iii) LNG is “F”; (iv) diesel is “D”; (v) car pool is “D”; (vi) riding bicycles are “B”, “C” and “D”; and (vii) reusing steam of boiler for heating purpose is “E”. Looking at overall performance, “F” is the best because of the biggest energy saving (25.90%) and the lowest cost per bed (11,937 Baht).

Table 5-5: Practices in Reducing Energy and Outcomes.

Environmental Practice	Outcome
1. Produce biogas from food waste or animal manure	"D" - Biogas from cow and pig manure Outcome: Replaced kitchen LPG by **50%** (10 tanks of 15kg) Or 444 $kgCO_2$/year
	"E" - Biogas from kitchen's food waste Outcome: Replaced kitchen LPG by **25%** (408,662B/yr) Or 455.4 $tonCO_2$/year
2. Use LPG, LNG and petrol instead of diesel fuels or electricity	"C" - Replace electric dryer by LPG energy Outcome: Increased LPG (35.93%) or 23,376 kg in 2012, to 31,776 kg in 2013. Or 24,860 $kgCO_2$
	"D" - Replace diesel boiler by LPG - Use car (petrol) instead of van (diesel) - Replace electric dryer by LPG Outcome: (i) Diesel decreased (10.27%). Or from 15,116 litres in 2012 to 13,564 litres in 2013. Or decrease of 4,159.36 $kgCO_2$ (ii) LPG increased (53.49%). Or 430 litres in 2012, and 660 litres in 2013. Or increase of 347.3 $kgCO_2$ (iii) Petrol increased 209.10% or from 330 litres in 2012 to 1,021 litres in 2013. Or increase of 1,596.21 $kgCO_2$ **Total CO_2 reduction of [(i) – (ii) – (iii)] is 2,215.85 $kgCO_2$**
	"E" -Replace diesel boiler by LPG -Use hybrid vehicles

Environmental Practice	Outcome
	Outcome: LPG boiler can reduce 221.01 tonCO_2/year or save 3.28 million Baht a year. "F" - Use NGV Ambulance Outcome: Reduced 4,788 kgCO_2/year, or save 380,000 Baht a year.
3. Car pool adoption	Adopted by "B", "C", "D", "E" and "F" Outcome: "D" transports personnel between hospital and city centre, so that each person saves 1,500-2,000 Baht a month
4. Ride a bicycle in the hospital	Adopted by "B", "C", "D" and "F" Outcomes: Only "B", "C", "D" highly use bicycle
5. Other strategy	"E" - Reuse boiler's steam in heating of e.g. laundry, sterilisation Outcome: Reduced 221.01 tons CO_2/year - Drive less than 90km/h
Overall Outcome of Energy-Saving Policy	"B" - Decreased 17.05%, cost per bed (12,711 B) **Success (2nd)** "C" - (i) Total energy cost increased by 30.39%, cost per bed (12,852 B) (ii) The volumes of diesel and petrol reduced by 1.69% from 33,956 litres in 2012, to 33,382 litres in 2013. Or Reduced 1,538.32 kg of CO_2, or 4,215 Baht. **Success (3rd)** "E" - Energy is reported with Electricity "F" - Decreased 25.90%, cost per bed (11,937 B) **Success (1st)**



	Year 2010	Year 2011	Year 2012	Year 2013
B	1,250,817.88	1,414,822.86	1,379,137.26	1,144,027.70
C		1,801,333.08	1,478,425.98	1,927,778.92
F	382,125.31	584,766.23	644,376.73	477,485.21

Figure 5-9: Graphs of energy expenditure in total.

5.5.2 Discussion

(i) Petrol and Diesel Fuels of "D" Hospital

From Table 5-5, the volume of petrol used by "D" increased by an almost incredible 209.10%. This is owing to the hospital using a car (uses petrol) in transporting 3-4 staff to visit the community, instead of a van (uses diesel fuel). This practice decreased diesel fuel by 1,552 litres (or 4,159.36 kgCO_2), which was replaced by petrol only 691 litres (or 1,596.21 kgCO_2). It leads to a large CO_2 reduction of 2,563.15 kg and cost saving.

(ii) Biogas Production of "D" and "E" Hospital

Biogas production and use in "D" was supported by the government authority. "D" uses manure, its own from pigs and cows, as an input for biogas production. This practice eliminates nearly all methane emissions, which is 21-23 times as powerful as carbon dioxide in trapping heat (NRDC, 2015). The report of "D" shows 50% kitchen LPG reduction. Still, the Nutritionist reported limited usage because of the low pressure issue. To increase pressure needs more manure, which is collected from the Animal Breeding Research Station that is located far away. Despite considerable effort, increasing transportation is not a green solution. The Director has noticed this weakness and continues producing biogas. This is because he wants to use waste effectively, to generate the lowest environmental impacts (e.g. waste and CO_2), and to be a learning centre for the community.

“E” effectively uses all of its food waste of about 500 kilograms a day to feed the biogas plant. This plant was supported by the cooperation of Chulalongkorn University and the Ministry of Energy (2012), which aimed to use “E” as a role model. The produced biogas can replace kitchen LPG by 25% or 455.4 tons CO_2/year. The significant carbon reduction and cost saving were highlighted as the key incentives.

(iii) <u>Energy Saving of “B” and “C” Hospitals</u>

“C”, “D”, “E” and “F” addressed energy-saving policy before 2010. But only “B”, which addressed this policy in 2013, can reduce energy by 17.05% without outstanding practice being applied. “B” has success factor(s) that have been uncovered. The total energy cost of “C” increased by 30.39%, particularly LPG that increased by 35.93% or 24,860 kg. LPG is mainly used in the Laundry, Kitchen and Thai Traditional Medicine. It led to a discussion about replacing LPG by biogas in the interview meeting. One staff member at “C” stated that the hospital used to produce biogas, but had to stop because of its low pressure.

(iv) <u>Improving Biogas Production and the Role of Government</u>

Three key problems have been found: biogas’s low pressure; insufficient feedstock; and, low biogas plant installation.

As stated in Chapter 3, biogas pressure can be improved by using a biogas improved pressure pump, a generation compressor, and increasing feedstock. Additionally, special modifications and design of the stove and oven should be considered. Feedstock can be donated, for example, by local markets, restaurants and schools. The produced biogas should be kept in a strong container like an LPG tank in order to improve pressure. As a consequence, the hospital may not need to feed the plant every day.

The biogas plant of “E” cost one million Baht and offers biogas for 500-bed hospitals. “E” has developed a biogas plant model for small hospitals, which other hospitals or authorities can ask for. Still, the initial investment in plant and equipment is very high so the government and the MOPH should support these elements:

- A biogas plant and equipment,
- Biogas production and usage guidelines,
- Education and monitoring, and,
- Design the stove and oven to use with biogas, or both biogas and LPG.

Concluding Remarks

All public hospitals are strongly encouraged to produce biogas to reduce use of kitchen LPG. The following inputs of biogas should be considered: food waste, manure, or wastewater.

5.6 Infectious Waste

Note: (i) IW refers to infectious waste, GW refers to general waste, and HW refers to hazardous waste.

(ii) There is a small difference of IW handling costs (10-12 Baht per kilogram), which does not affect the analysis.

(iii) This section includes HW management.

5.6.1 Analysis

(i) Overview of Infectious Waste Management

As discussed in Chapter 3, Infectious waste (IW) is suspected to contain pathogens; incineration can destroy viruses or microbes contained in it (e.g. WHO, 1999, p.2, Xie and Zhu, 2013). Key best practice identified by WHO (2004) is waste reduction and segregation. This results in smaller quantities of IW being incinerated, reducing emissions and other hazards. Thus, this section focuses on practices that support waste reduction, segregation and hygiene.

There are some basic regulations that all public hospitals have to comply with, such as: (i) sorting waste properly; (ii) differentiating transportation routes for food, clean linen, medical device, and waste; and (iii) storing IW in a temperature-controlled room (PCD, 2010, PCD, 2013b). These are well acknowledged by all case hospitals. From hospital visits, IW was mainly generated by wards, operating theatres, laboratories and central sterilisation supply departments. To support waste segregation, sufficient waste bins for GW, IW, HW, sharps, food waste, and recyclable waste should be provided. For example, IW is disposed of in a red bag, while sharps waste is stored in a strong and fully-closed container.

(ii) IW Practices

According to Table 5-6, case hospitals often started waste-sorting programmes by educating their employees, and observe the accuracy of waste sorted. Wards generally have several types of waste bin (e.g. used linens, IW, HW and recyclable waste), which patients and their relatives can use wrongly. As a result, nurses on the wards of “B” and “F” habitually educate patients and relatives to sort waste correctly.

In “C”, patients are sometimes educated about sorting waste by housekeeping workers. Obviously, “C” has applied the most variety of practices, which would infer the highest structural waste management. For instance, all waste bags are tagged at source, so that the housekeepers can check the mixed waste and provide feedback correctly. “C” also uses transparent waste bins, encouraging people to dispose of waste using the correct bin. Some of its hazardous waste is returned to suppliers. All types of waste management in “C” are controlled by the Head of Infection Control (IC). The Head stated that this centralized system is more effective than the Env Team.

(iii) <u>Practice Outcomes</u>

Note: Each hospital uses different methods to evaluate the accuracy of waste sorted, so it is less important to measure waste performance than the volume and trend of IW.

Starting with the accuracy of waste sorted, “C” was rated by its housekeeping worker at only 20%. This is because she often found mixed waste, because many staff members sorted waste wrongly. “D” has adopted fewer practices than “C”, and has the lowest number of housekeepers per bed (1:5), but gains 98.77% of accuracy. The low waste performance of “C” is because the Head of Infection Control has been on study leave for two years, resulting in lower monitoring and encouragement. The practice of “C” can also be considered as poorly established.

Considering IW volume, “B” may be the best practitioner because of the greatest reduction of 24.21%. This contrasts with increasing patient numbers (1.1-4.3%). Looking at IW cost per bed, the performance of “D” is also good, because of having only 147 kg/bed. Still, “B” with IW of 195 kg/bed should be the best because it has more specific medical treatments that often generate a larger amount of IW than “D”.

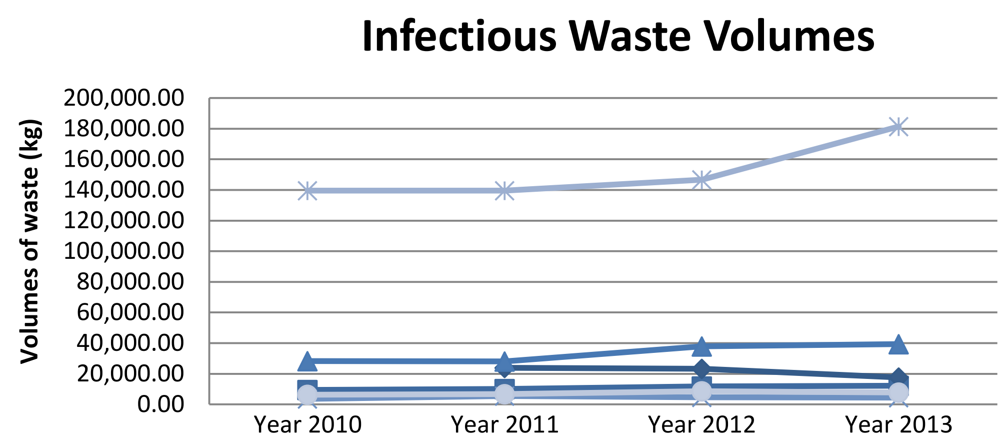
Table 5-6: Reducing Infectious Waste Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Number of housekeeping workers	7	1 worker for 1 department	28	6	5 (Only waste collection	6
Housekeeping workers per bed	1: 8.6	No Data	1: 5.4	1: 5	No Data	1: 6.7
1. Educate staff in sorting waste	Yes	Yes	Yes	Yes	Yes	Yes
2. Educate patients and visitors in sorting waste	No	Yes (By ward)	Yes (housekeeper	No	No Data	Yes (By ward)
3. Regularly check the accuracy of waste sorted	Yes (Once a year)	Yes (e.g. Heads monitor their subordinates)	Yes (housekeeper can report of mixed waste)	Yes (every week, and report of mixed waste)	Yes	Yes (By the Waste Team)
4. Provide waste containers in different colours/sizes/type	Yes (Coloured-containers)	Yes (Large-sized containers)	Yes (Transparent containers)	Yes (Coloured-containers)	Yes (Transparent containers)	Yes (Coloured-containers)
5. Use foot-pedal waste bin for facilitating use and hygiene	Yes	Yes	Yes	Yes	Yes	Yes

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
6. Sufficiently monitor e.g. waste collection and protections of housekeeping workers	No (By IC)	Yes (By IC and Committees)	No (By Head of Env Team)	Yes (By Env Team and IC)	No	Yes
7. Sharps are disposed of into strong and fully-closed containers	Yes (Old desert tin-bucket)	Yes (Softener's gallon)	Yes (Plastic waste bin)	Yes (Softener's gallon)	Yes (Softener's gallon)	Yes (Softener's gallon)
8. Show a poster of how to sort waste near waste bins	Yes	Yes	Yes	Yes	Yes	Yes
9. Collection of GW and IW by different persons, to increase hygiene	No (Done by a housekeeper)	Yes (IW is done by a worker)	Yes	No (Done by a housekeeper)	Yes (IW is done by a worker)	Yes (IW is done by a worker)
10. Always tag source and type of waste on waste bag	No	Yes (Sometimes)	Yes (Always)	No	No	No
11. Monitor the performance of third parties (or waste handlers)	Yes	Yes	Yes	Yes	Yes	Yes
12. Leave a little waste in a bin, so people dispose of waste correctly	No	No	Yes	No	Yes	No

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
12. Other Practice	"A" - Contact vendor e.g. Toshiba to collect HW - Bury HW in hospital safe premises "B" - Contact the municipality to collect HW "C" - Centralized control waste management by Head of IC - Reduce IW weight by separating liquids - Tag nearly expired drugs in colour to remind staff to use - Return fixture and formaldehyde bottle to suppliers "D" - Burry HW in hospital safe premise "F" - Check IW's volume of all department to identify cause of increase						
Outcome: 1. The accuracy of waste sorted	80%	90%	20% (Interview)	**98.77%**	70-75%	No Data
2. The volume of IW and handling cost	Increased (3.28%), per bed (203 kg or 1,830 B)	**Decreased** **(24.21%)**, per bed (195 kg or 2,029 B)	Increased (4.32%), per bed (263 kg or 2,628 B)	**Decreased** (6.37%), per bed (**147 kg**, or 1,765 B)	Increased (23.77%), per bed (348 kg)	Decreased (9.76%), per bed (193 kg, or 1,450 B)
3. Housekeeping workers follow guidelines correctly (observation	Low (60% behave	Low (e.g. ware	High	High	Very low (e.g.	High

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
and interview)	wrongly e.g. throw a waste bag)	incomplete protections)			overflowing garbage)	
Summary	**Failure**	**<u>Success (1st)</u>**	**Failure (Discuss)**	**Success (2nd)**	**Failure**	**Failure (Discuss)**
<u>Current Barrier</u>: **-** Employees sort waste wrongly, because of low attention	Yes	Yes (Low)	Yes (High)	No	Yes (High)	Yes
- Patients and relatives sort waste wrongly	Yes (Most are foreigners)	Yes	Yes (They are illiterate)	Yes	Yes	Yes (Most are foreigners)
- Help handle IW from sub-district hospitals, this waste is mixed.	No	Yes	Yes	No	No	No
- Cannot differentiate transport routes of e.g. waste and garment.	Yes	Yes	Yes	Yes	Yes	Yes
- Do not have a temperature controlled room for IW	Yes	Yes	Yes	Yes	Yes	Yes



	Year 2010	Year 2011	Year 2012	Year 2013
A	9,432.00	9,975.00	11,813.00	12,201.00
B		23,911.00	23,155.00	17,549.00
C	28,247	28,091	37,788	39,420
D	3,601	5,458	4,712	4,412
E	139,621	139,555	146,594	181,443
F	6,284	6,722	8,546	7,712

Figure 5-10: Graphs of infectious waste volume.

5.6.2 Discussion

(i) <u>General Drivers of Addressing Waste Management</u>

Hospital Accreditation (HA) was introduced to Thai public hospitals 10-15 years ago; structured waste management is one of its requirements. As mentioned, awarding HA is related to increased budget allocated. This really motivated the hospitals to establish waste management systems. The long period of the adoption can be classified as the mature stage (INAP, 2010). Still, the mixed waste problem of case hospitals is often found. Interestingly, the highest ranking staff, such as administrators and physicians, still sort waste inaccurately, owing to low attention.

(ii) <u>Issues of "E" Hospital</u>

"E" shows the highest growth of IW volume, 23.77%. This is more than double that of its patients' volumes that have grown only 4.4-10.8%. "E" also has the following waste management issues: overflowing waste, waste bag leakage, and incomplete protection. This reflects a lack of monitoring and correction.

Overflowing waste would be solved by providing a larger-sized bin or more frequent waste collection; while selecting thicker waste bags can solve the leakage issue. The cause of these problems was claimed by “E” to be that the hospital size is too large to provide sufficient monitoring. Although, Table 5-6 reveals that only “E” has specific workers to collect GW (4 persons) and IW (1 person), whereas other case hospitals assign housekeepers to do both collecting waste and cleaning. Respectively, the performance of “E” can be identified as low.

(iii) <u>Others</u>

In other hospitals, like “D”, it is not only the Head of Infectious Control who monitors housekeeping workers’ performance, but it is all employees’ responsibility. “F” has decreased IW volume by 9.76%. Nonetheless, its performance is not the best because the decreased IW volume is related to the reducing patient numbers. Likewise, “F” has low IW per bed (193 kg) which is quite similar to “B” (195 kg) but “B” has more specialists who can generate a larger IW volume. Lastly, no case hospital has a temperature-controlled waste storage room. Reasons given include: (i) insufficient budget; and (ii) the pathogens are not growing in that limited time (within five days).

Regarding hazardous waste (e.g. electronic waste), “A”, “B” and “C” have reported difficulty in finding waste collectors. They have contacted the government authorities, such as the Pollution Control Department. The problems are: (i) they provide no clear information or contact lists of waste collectors; or (ii) the waste collector can collect only some types of waste; or (iii) there is a small number of HW handlers in Thailand. “B” is helped by the municipality to collect this waste, while “A” and “C” have to handle this issue by themselves. Because this hazardous waste requires special treatment, the government should pay greater attention.

<u>Concluding Remarks</u>

Two important practices for successful waste segregation are: (i) sufficient monitoring of staff disposal habits, including inpatients (on the wards) and visitors in the programme; and (ii) giving feedback on the accuracy of waste sorted to the department.

5.7 Recyclable Waste

Recyclable waste can be classified into two types: one is general recyclable waste (e.g. cardboard, paper, glass bottles, plastic bottles and saline tubes); the other is electronic recyclable waste. Both are often collected and sold to nearby recycling shops (see Table 5-7). From observation during hospital visits, this waste is often mixed with general waste (GW) that always ends up in landfills. Correspondingly, establishing a recycling programme reduces the amounts of GW, recyclable waste, carbon emissions (0.842 $kgCO_2e/kg$) and increases revenues.

Note: Recycling waste prices from different regions are quite similar, which supports identifying best practice.

5.7.1 Analysis

(i) <u>Recyclable Waste Practices</u>

In “A”, “D” and “E”, collecting recyclable waste is the responsibility of housekeeping workers or the departments that produce recyclable waste (e.g. Pharmacy and Administration). Subsequently, revenues from sale of waste are returned to them, not to the hospital as a whole. “B”, “C” and “F” have established recycling banks. This is based on the idea that much of the waste was once a hospital resource. That is why the largest proportion of revenue from selling waste (70-80%) should be returned to the hospital. The remaining revenue (20-30%) should be given to housekeeping workers or departments who collect and send waste to the bank.

Operating the bank is very challenging, because there is growing resistance from persons who lose financial benefit. This is one of the major reasons that halted the bank operations of “E”. To overcome this barrier, the Director of “B” has provided a clear explanation, reward system and proper correction. Also, 5S[6] competition is organized to increase engagement. “C” has adopted multiple

[6] 5S is a Japanese method to organize the workplace, including seiri (cleaning up), seiton (organizing), seiso (cleaning), seiketsu (standardization), and shitsuke (training and discipline).

practices such as establishing a structural team to manage the bank, and sorting waste at source (by all employees). “C” sorts waste again at the bank according to selling prices (e.g. paper is sorted into colour, white, magazine and newspaper). Because “C” has many types of waste, “C” selected a recycling shop that can collect all waste, rather than one that offers higher price but can collect only some of the waste.

(ii) Practices’ Outcomes

From Table 5-7, “D” and “F” have increased volumes of recyclable waste; which are 38% and 30% respectively. The performance of “D” equates to CO_2 reduction of 2,484.7 kg in 2011. Nevertheless, this does not tell us who is the best because “F” has a recycling bank, while “D” does not. Besides, “F” shows the highest revenue of selling recyclable waste per bed, 534 Baht. But the recycling banks of “B” and “C” show reducing waste trends; which are 8.48% and 52.86% respectively. This would mean lower performance in reducing carbon emission or managing waste.

Note: “A” has learned how to operate a recycling bank from “T” medical school, which plans to establish the bank soon. Yet, the current problem is a lack of an identified responsible person.

Table 5-7: Practices on Recyclable Waste and Outcomes.

<table>
<tr><th>Environmental Practice</th><th>A (60 B)</th><th>B (90B)</th><th>C (150B)</th><th>D (30B)</th><th>E (528B)</th><th>F (40 B)</th></tr>
<tr><td>Overall Practice</td><td>Sell by maid/ department</td><td>A recycling bank</td><td>A recycling bank</td><td>Sell by maid/ department</td><td>Sell by maid/ department</td><td>A recycling bank</td></tr>
<tr><td rowspan="4">Other Practice</td><td colspan="6">“A” - Maids or departments can sell waste and collect the revenue</td></tr>
<tr><td colspan="6">“B” - (i) Has a bank controller, (ii) Ask support from heads, (iii) Has 5S competition, (iv) On-going communication, (v) Set a clear revenue allocation, and (vi) Sell waste to vendor that gives the highest price</td></tr>
<tr><td colspan="6">“C” - (i) Controlled by a team, (ii) Collect and weigh waste every day, (iii) Set a clear revenue allocation, (iv) Sort waste at source, (v) Sort waste again based on prices, (vi) Include waste from a residential area, (vii) Choose vendor that collects all waste types, and (viii) Main revenue is added to a hospital fund</td></tr>
<tr><td colspan="6">“D” - (i) Maids or departments can sell waste and collect the revenue, (ii) The volume of waste sold has to be reported, and (iii) Focus on cardboard, paper, glass bottle and plastic bottle</td></tr>
<tr><td>Outcome:
1. A volumes of recycling/reusing waste and revenues</td><td>No Data</td><td>Year 2011:
8,200 kg
(36,163 B);
Year 2012:</td><td>Year 2011:
30,697 kg
(132,606 B);
Year 2012:</td><td>Year 2010:
2,138 kg
Year 2011:
2,951 kg</td><td>No Data</td><td>Year 2011:
24,086 B
Year 2012:
16,436 B</td></tr>
</table>

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
		7,489 kg (31,504 B); Year 2013: 7,505 kg (30,501 B) (Decreased 8.48% year 2011-13)	23,952 kg (82,482 B); Year 2013: 14,470 kg (62,188 B) (Decreased 52.86% year 2011-13)	**(Increased 38%)**		**Year 2013 :21,384 B (+30.11% of year 2012-13)** (the volume – kg was not given)
2. Carbon reduction ($kgCO_2$) from reducing volume of general waste (0.842 $kgCO_2$/kg)	No Data	Year 2011: 6,904.4 Year 2012: 6,305.7 Year 2013: 6319.2	Year 2011: 25,846.9 Year 2012: 20,167.6 Year 2013: 12,183.7	Year 2010: 1,800.2 Year 2011: 2,484.7	No Data	No
3. Amount of recycling waste (kg) and revenue per bed	No Data	83.4 kg, 340 B.	96.5 kg, 415 B.	98.37 kg	No Data	**534 B.**
Summary	**No**	**Failure (Discuss)**	**Failure (Discuss)**	**Success**	**No**	**Success**

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Current Barrier:	-No recycling bank, due to no volunteer	-Department sells waste by itself	- Limited bank's space -Staff do not usually sort waste	No	No	No

5.7.2 Discussion

All housekeeping workers stated the volume of recyclable waste usually varies by the numbers of patients and visitors. “F” has a U-shape trend of recyclable waste volumes: 2011 – 24,086 kg, 2012 – 16,436 kg, and 2013 – 21, 384 kg. This is closely related to outpatient volumes (2011 – 83,344; 2012 – 80,649; 2013 – 84,863). Respectively, the garbage bank of “F” can be the best.

Observing “B” and “C” found several uncommon issues discussed below. Firstly, “B” and “C” should have greater volumes of recyclable waste and selling revenues than “F”. This is because of their larger sizes, increasing volume of patients and very systematic recycling banks. But, the table clearly shows that “F” has a higher revenue per bed (534 Bath) than “B” (340 Baht) and “C” (415 Baht). And it is very interesting that “B” and “C” waste volumes and revenues are greatly declining; which contrasts with increasing patient numbers.

The explanation given by the Director of “B” was that some departments like Pharmacy sometimes sell the waste and collect revenue independently. This problem has been constantly occurring; in spite of this, the policy was well-informed.

In “C”, its report mentions the reducing volumes of recyclable waste. But its housekeeping workers mentioned that the volume of recyclable waste has greatly increased; waste has been collected every day rather than three days per week as previously. This different information may signal misunderstanding between workers and the bank, or incorrect data reported (both volume and revenue), or both. Consequently, “B” and “C” cannot be the best practitioner.

Concluding Remarks

Establishing a garbage bank is highly recommended for hospitals that have a large amount of waste. The clear allocation of revenue should be embedded, as a part of HA guidelines. Whether the recyclable waste is managed by the bank or personnel, it should have effective waste segregation, collection and recording systems.

5.8 Paper

As stated by many respondents, paper is the key category of office supplies. This paper system is the main communication method of the government authority, ranging from medical records to administration tasks, and for both internal and external communication. Documents containing errors cannot be submitted and need to be reproduced. In consequence, the quantity of paper used is extremely large. As mentioned in Chapter 3, using a ream of paper equates to emitting 5.4 $kgCO_2$. As a result, decreasing paper use reduces paper waste and carbon emissions.

5.8.1 Analysis

Note: Data on amounts of paper used are neither given to external parties nor shown in the financial report. Hence, this was mainly obtained from the interviews.

(i) Practices of Paper Use

Table 5-8 presents several practices to reduce paper, including reusing paper, limiting the volume requested and using an information system. Some hospitals have a separate shelf or box to keep one-side used paper, to be reused later. Even though six case hospitals have established a reducing paper use measure, only "C" and "D" constantly record and review their paper use. The local publishing house often donates one-side-used paper to "E", so that the other side of the paper can be used for printing or working. As reported by the Administration Department of "F", 70 gramme paper was selected for printing instead of 80 gramme, in order to reduce paper expenditure.

Note: A pay-for-performance scheme (P4P) was introduced in 2013, by which the new medical salary system is based on the employee's workload. Thus, all employees have to submit a paper report showing their amount of work.

(ii) Practice Outcomes

The findings indicate that paper use reduction is evident in "C" and "D". "C" decreased the use of paper by 53.77% or from 1,127 reams in 2012 to 521 in 2013. This compares to reducing CO_2 by 3,272.4 kg. "D" had a smaller reduction of paper than “C”, of 14.85% or from 330 reams in 2012 to 281 in 2013. This equates to 264.6 kg of carbon reduction. Although, in terms of paper per bed, “C” had only 3.43 reams while “D” reached 9.36 reams. At that time, “C” was in the hospital accreditation (HA) process, which requires preparation of a large volume of paper documents. But, “D” did not apply for HA during that time. As a consequence, the practices of “C”, such as reporting systems when found single-side paper use, appeared the most successful.

Table 5-8: Paper Reduction Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Reuse paper	Yes (Sometimes)	Yes	Yes (Reports if found non-reuse paper)	Yes (Interview and observation)	Yes (white paper and carbon paper)	Yes
2. Keep one-side use paper, to be reused later	Yes (Some areas)	Yes (Some areas)	Yes (Compulsory)	Yes (Compulsory)	No Data	Yes (Some areas)
3. Limit paper requested	Yes	Yes	Yes	Yes	Yes	Yes
4. Use information system to record and transfer data	-HOSxP (main area)	-Himpro (main area) -DRUG (Pharmacy)	- HOSxP (across the hospital) -RMC 2013 (Maintenance)	-HOSxP (main area) -DRUG (Pharmacy) -e-Office (Administration)	-HOSxP (main area) -MS Excel (Medical Stock) -Zimbra (Administration) -HOMC	-HOSxP (main area) -RMC 2012 (Maintenance) -MS Excel (Medicine and Office Supply

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
					(Pharmacy)	Stocks)
5. Frequently record and review paper used	No	No	Yes	Yes	No	No
6. Other practice	No	No	- Contact vendors by using a LINE application (e-catalogue)	No	- Use another side of paper donated by published house	-Use 70 gram paper instead of 80 gram -Use used paper to protect blood
Outcome: Volume of paper use	Result of reducing paper is a failure (Interview)	A small reduction of paper use (Interview)	Year 2011 is 1,241 reams; year 2012 is 1,127 reams; **year 2013 is 521 reams (-53.77%), or 3.43 reams/**	Year 2012 is 330 reams; Year 2013 is 281 reams (-14.85%) or 9.36 reams/ bed	Paper use is increasing. The reducing paper policy impacted on paper used less than 1%. (Interview)	Year 2012 is 430 reams, year 2013, is 553 reams (+23.95%) or 13.82 reams/ bed

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
			bed			
Environmental benefit per year	No	No	**Reduced 3,272.4kgCO$_2$**	Reduced 264.6 kgCO$_2$	No	Increased 664.2 kgCO$_2$
Summary	**Failure**	**Failure**	**Success(1st)**	**Success(2^{n})**	**Failure**	**Failure**
Current Barrier: 1. Hospital Accreditation (HA)	Yes	Yes	Yes	No	Yes	Yes
2 E-Government Procurement (e-GP)	No (in training)	Yes	Yes	Yes (in 2013)	Yes	No
3. Pay-for-performance (P4P)	Yes	Yes	Yes	No Data	Yes	Yes
4. HOSxP	Yes	No (Himpro)	Yes	Yes	Yes	Yes
5. Others	-Old photocopier uses more paper	-Staffs use hospital paper to print their children's homework or examination	No	No	-Increasing departments and workload -Old printers use more paper	-Old printers use more paper -Foreign patients use more paper

5.8.2 Discussion

(i) <u>Success Factors of Reducing Paper</u>

Clearly, the practices adopted by the six case hospitals are quite similar, but they have small differences in detail. For example, they all reuse paper, but only “C” has a strong reporting system. The Director of “C” has allowed housekeepers to inform the Head of Department when they see non-reused paper in the waste bag. The Head in turn informs subordinates to practise better paper use and management to avoid wastage of this nature. Additional interviews revealed that this reporting culture is generally in place in the public hospital to support continuous improvement. In addition to this, only “C” and “D” can provide data on paper use immediately after it was requested due to the efficiency of their robust reporting system and adherence to the hospital policy.

(ii) <u>Causes of Failure to Reduce Paper</u>

Other hospitals’ practices are unsuccessful because of these barriers: (i) “A” has only one old photocopier that consumes a large volume of paper; (ii) “B”’s employees often use the hospital’s paper to print their children’s homework or examinations, creating an ethical problem; (iii) “E” has increased the number of departments and workload; and (iv) “F” has never reviewed the volume of paper used. The printers and photocopiers in “A”, “E” and “F” are old and often broken. They cannot continuously feed sheets in at a steady rate, print two sides and produce uneven and light print.

(iii) <u>Paper-Based System of the Government</u>

Although the electronic information system has been of increasing importance, the paper-based system is principally used. For instance: (i) use of letters instead of email; (ii) printing on one side of the paper in submitting documents to external parties; (iii) keeping key records (e.g. finance and medical records) in paper form for 5-10 years; and (iv) producing the reports of meetings according to the number of departments/ attendances. For instance, “E” prints 75 sets of meeting reports for its 75 departments.

Respondents suggested using intranet, email and saving data on CD or database to reduce paper use and effectively share/transfer information among users. The interesting point is that while the government promotes sustainable policy, its paper-based system increases use of paper and paper waste.

(iv) Paper-Based Resource Requisition and Purchasing

Figure 5-11 shows all paper forms to be completed in processing resource requisition, purchasing and receiving new items within the hospital. Each of them must have at least two copies: one is kept by the source department, and another is kept by, for example, the stock and purchasing office.

Before the year end, all hospital departments have to complete an annual purchasing plan, which covers all resources needed for the following year. This plan is later approved by the Director and helps control resource use and budgeting. During the year, a user (all departments) selects general supplies as shown in the handbook, and submits a completed requisition form to the stores. For instance, requests for stationery have to be sent to the Office Supplies stock, which later delivers the item needed.

Specific items that are used in only some departments (such as wheelchairs and crutches in the Occupational Therapy Department) need to be purchased separately from general supplies. The requisition form must state specifications of product needed and potential vendors, because the user department knows this information the best. This form is submitted to the Office Supplies and is first approved by the hospital purchasing committees, followed by the Director. After that, a purchasing officer contacts a potential vendor and places a purchasing order (PO). This is done by using fax and/or post, supplemented by a phone call. The number of POs varies by the hospital size. For instance, Pharmacy Stock of "E" issues 50 POs a week or 2,000 POs a year.

The vendor can deliver the products and invoice directly to the hospital stores or the department that requests the product. Before placing new items on the shelf, receiving committees have to check that item (e.g. condition, expired date and number) compared with a PO and invoice. Finally, all these documents are manipulated for making a payment. In short, purchasing only a single specific item may need 5-10 pieces of paper.

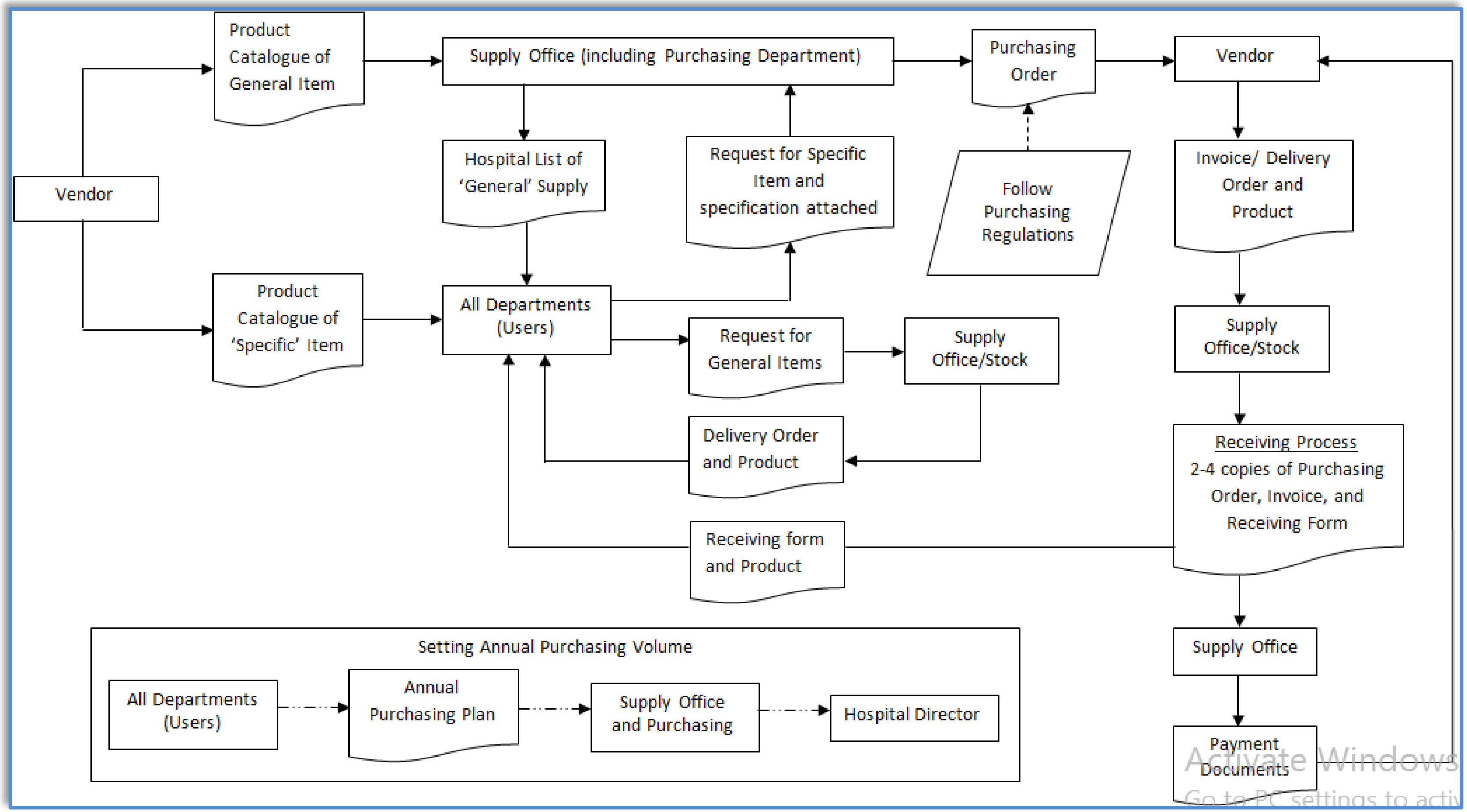


Figure 5-11: Resource requisition and procurement processes diagram.

Source: Author.

(v) HOSxP and e-GP

HOSxP is a programme developed for the hospitals to collect data of, for example, patients and resources. The previous government had enforced a requirement in all public hospitals to produce an annual report, according to the format provided by HOSxP. Consequently, many hospitals have to address this system, although it is not well-developed. This leads to many problems such as allowing the users to request non-existent items, the system being unstable and breaking down, and increasing use of paper. For instance, previously the hospital could reuse the OPD card several times, but using HOSxP they have to print new OPD documents for each visit. This unstable system makes the large stock pharmacies prefer using a manual system to prevent the risk of being unable to access data.

Similar to HOSxP, the Electronic Government Procurement (e-GP) was only half-completed when introduced to all public hospitals. In consequence, it is quite unstable and time consuming. For instance, completing one purchasing order takes up to ten minutes. Generally, e-procurement concepts support online processing of, for example, product selection, placing orders and making payment (Piotrowicz and Irani, 2010). But, e-GP supports only selecting products from the government's list and completing a structured purchasing form. Additionally, the government authority cannot make any payment before receiving the product; thus e-procurement that usually makes a payment first is rarely applied.

(vi) Paper System VS Information System

Paper documents are permanent evidence that support fraud prevention. Printouts are easy to read and manage for the people who are not familiar with the computer system. But it offers low-integration and exchange of information, needs large storage space, is difficult to adjust, is time consuming, and requires more computer supplies (cartridge, printer, computer, etc.).

The above problems can be solved by the information system. Many key hospital areas have installed different information systems, resulting in low data exchange that can affect medical services. For example, the doctor sometimes prescribes medicines that are already running-out, because medicine stock limits the access.

Subsequently, a fully-integrated IT system in a single hospital is needed. But lack of budget and knowledge can make this a long-term planning issue. Also, the government may consider sharing data between hospitals and public health authorities. It needs to be supplemented by studying the advantages and disadvantages of increasing computer supplies and electricity usage; as well as effective management of electronic waste.

Concluding Remarks

To efficiently save use of paper, the hospital should focus on reducing paper requested and used, as well as reusing paper. The most necessary practice adopted is establishing an effective reporting system. This means all paper waste is observed, and disposal of non-reused paper is reported. Importantly, a soft corrective measure after receiving the report should be used to reduce resistance and conflict.

5.9 Organic Food Materials and Herbs

Hospital kitchens often produce about 5-10% more food than is actually needed because of the unpredictable volume of patients admitted. Furthermore, since many patients and their relatives are poor, so “B”, “C” and “D” also gave food to relatives. Food services can be operated by the hospital or outsourced. Every day, the ward will notify the kitchen about food needed (both type and quantity), using a paper form, telephone call and online system. Apart from the kitchen, the hospital often has a canteen and food shops for staff and visitors.

5.9.1 Analysis

Table 5-9 shows several food practices, such as economical use of food materials, increasing volume of organic foods and managing food waste effectively. Focusing on organic foods, only the hospitals that use in-house catering service (“C”, “D” and “E”) can select organic/local/seasonal food materials. Outsourcing the supply service means the third party can select raw materials to deliver to the kitchen.

“D” uses own-grown rice, vegetables and egg to produce food for patients and employees. These organic products account for 20% of total food materials, and represent a cost saving on food supply. Employees of “D” can take vegetables and fruits (e.g. banana and papaya) back home, because they help to grow these products. Both “C” and “D” receive organic agricultural products from their employees and local organic farmers. Thus, the patients’ menus are adjusted according to the availability of food materials. Generally, the hospital often notifies farmers in advance about the required items.

“C” has produced several herbal products (e.g., tablets and drinks) from its own herb garden, in order to feed its Thai Traditional Medicine Department, and to sell to other hospitals. Lastly, most of the case hospitals are reducing meat consumption by adding more beans and vegetables in the patients’ menus, following the Health Promotion Policy. Food waste is usually given to a local farmer, fed to hospital animals (dogs and cats), and used to produce biogas or fertilizer.

Table 5-9: Practices for Organic Foods, Food Waste Management and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Kitchen is in-house or outsource?	Outsource	In-house	In-house	In-house	In-house	Outsource
Food requisition	paper/phone	paper/ phone	online/phone	visit ward/ phone	online/phone	paper/phone
1. Produce food according to the volumes of inpatients	Yes	No (Give to poor visitors)	No (Give to poor visitors)	No (Give to poor visitors)	Yes	Yes
2. Grow organic vegetables, fruits and herbs	Yes (Vegetables and fruits)	No (Limited space)	Yes (Herb)	Yes (All of them)	No (Limited space)	No (Limited space)
3. Select organic/local/seasonal materials to produce foods	No	No	Yes (By organic farmers)	Yes (By Hospital and farmers)	Yes (Only organic rice)	No
4. Reduce meat, and add more vegetables in food menus	Yes	Yes	Yes	Yes	Yes	Yes
5. Reuse food waste	Give to a local farmer	Give to a local farmer	Produce fertilizer	Feed animals	Produce biogas	Feed animals
6. Other green practice	No	No	-Notify	No	-Organize	No

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
			farmers in advance -Organize green market - A Healthy food shop		green market -A Healthy food shop	
Outcome	Fruits and vegetables are given for free	No	**Adjust food menus as inputs availability**	**20% of food materials are from hospital garden**	No Data	No
Summary	**Failure**	**Failure**	**<u>Success</u>**	**<u>Success</u>**	**Failure**	**Failure**
<u>Current Barrier</u>:	-Insufficient support	-Organic farmers have insufficient products	No	No	-Organic farmers have insufficient products	No

5.9.2 Discussion

“D” has adopted ‘organic farming and foods’ owing to the Director’s view that it is the best way towards sustainable health; and to be a learning centre for organic farming. This is owing to most villagers in that district previously using chemical-based farming. This had led to sickness in both farmers and consumers, which increased the number of patients requiring medical care. Respectively, chemical-based farming indirectly results in the increasing use of hospital resources; organic farming and foods can successfully solve this problem. The key concept adopted from the SEP is *“Grow everything we eat, and eat everything we grow”*.

“D” has encouraged this practice for 6-7 years, and most villagers have learnt and follow the hospital ways. They include organic farming, producing EM and organic fertilizer, and sorting waste and selling recyclable waste. “D” conducted a survey and found that these practices can support health, reduce use of chemical products, and increase cost-saving. These are the key reasons that deliver reductions of both patient numbers and medical resource usage. These practices strengthen the economy of the hospital and community, as well as the local organic farming network. In addition, it reduces transportation, generating reductions of fuel consumption and air emissions.

Note that “D” has successfully adopted this practice owing to its location in the countryside with a large amount of free space. Also, it is located in a small community that has a close relationship with the villagers. In contrast, hospitals located in an urban setting may not be as successful as “D”.

Concluding Remarks

The hospital should farm organically (e.g. rooftop and wall gardens), or purchase organic food materials, or both whenever possible. Then, the healthy food menus need to be adjusted based on organic inputs available, to serve patients and staff. In achieving a closed loop supply chain, the hospital should use its own produced fertilizer and EM; and reuse food waste as biogas or EM inputs.

5.10 Effective Microorganisms (EM)

Effective microorganisms (EM) was developed by Teuro Higa of the University of Ryukyus (Japan) Japan in the 1970s (Higa and Parr, 1994). EM was defined as *"the use of mixed cultures of beneficial and naturally-occurring microorganisms as soil inoculants".* EM, as explained by the Department of Health (DOH, 2015, no page), is a liquid product from the fermentation of sour fruits, vegetables, and food waste with brown sugar/molasses and water.

5.10.1 Analysis

(i) <u>The EM Production Procedure</u>

The EM production procedure was mainly explained by "A", "C" and "D"; their formulas and cost calculation are very similar as follows. Regarding the formula for EM production of 50 litres, it requires:

-	0.5 litre of EM (hospital can produce by itself)	=	No Cost
-	1 kilogram of brown sugar/or 1 litre of molasses	=	25-30 Baht
-	Sour fruit waste 1-2 kilograms	=	No Cost
-	Water (50 litres) (Water cost is relatively low.)	=	Low Cost

Therefore, the total cost per 50 litres of EM is approximately 25-30 Baht (or 0.5 GBP). "A" (60 beds) often produces 600 litres of EM every 2-3 months, while "C" (150 beds) produces 300-400 litres of EM per month. Interviewees stated that fruit's EM has a better smell than food waste's EM because of citrus, which is not disturbing to patients and visitors. Generally, the fermentation takes 2 weeks to a month.

(ii) <u>EM Practices</u>

The pure EM liquid has to be diluted before it is principally used as organic liquid fertiliser, and an odour remover for the wastewater treatment plant (see Table 5-10). Furthermore, the residue from EM fermentation can be used as fertilizer. Commonly, discharged wastewater from using chemical products (e.g. detergent and soap) often kills beneficial microorganisms in the wastewater treatment plant. Pouring small amounts of EM liquid into the plant every week can both support the microorganisms' work and reduce odour. "A" and "D" use pure EM liquid to produce these products: liquid soap, dishwashing liquid, floor cleaning liquid, washing liquid, and sterilisation liquid. This can be done by adding other ingredients such as salt, thickener and flavours. These products can be kept in the barrels for over a year. Users (e.g. housekeeping workers, clinics, and wards) request and collect the EM products needed. Other effective strategies include having a responsible person producing EM as well as on-going checking of its quality and quantity.

(iii) <u>Practice Outcome</u>

Case hospitals have not recorded the data of both EM production and usage volumes; hence the data were mainly given by the interviewees. For instance, the gardener of "A" (60 beds) shows approximate cost saving as:

- Annual cost of EM Production	(15,000) Baht
- EM replaces liquid soap of 2,300 litres * 45 Baht/litre	103,500 Baht
- EM replaces sterilisation solutions	<u>300,000 Baht</u>
Total cost saving [-15,000+103,000+300,000]	**<u>388,500 Baht</u>**

The above figures do not include organic fertilizer, odour remover, and dishwashing liquid. Therefore, the real total cost saving would be greater than 400,000 Baht, for the 60-bed hospital. As shown in Table 5-10, "A" and "D" have good performance, due to: (i) replacing use of many chemical products; (ii) on-going use of EM across the hospital; (iii) good quality of EM; (iv) improving quality of wastewater; (v) effective use of fruit and vegetable waste; and (vi) high cost reduction. But, EM of "D" is the most successful, because of high capability in cleaning the floor of Operating Room (OR) and 90% of medical tools (metal ware and glassware). These two areas require the highest standard of cleanliness. EM of "B" that is used for treating wastewater is thus identified as of lower performance than "A" and "D".

Note the hospitals that do not officially use EM in cleaning processes ("B", "C", "E", and "F" Hospitals) generally use chemical products. And thus, their chemical wastewater discharged really impacts the function of the wastewater treatment plant, killing beneficial microorganisms.

Table 5-10: Practices on Effective Microorganism (EM) and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Produce and use a variety of EM products	Yes (e.g. dishwashing liquid, floor cleaning liquid, and liquid soap)	No (Reduce the odour of wastewater and killing mosquito larvae.)	No (Clean floors and toilets, and support waste water treatment.)	Yes (e.g. Sterilisation liquid, dishwashing liquid and liquid soap)	No (EM is a by-product of biogas, having a low usage)	No (Given by Land Development Department to treat wastewater)
2. Use hospital's resource/ free resource/ waste as EM's input	Yes (e.g. lemon, orange and bergamot given by the market)	Yes (vegetable waste from kitchen)	Yes (bergamot given by employees, and own herbal waste)	Yes (bergamot given by villagers)	Yes (food waste from kitchen)	No
3. Check EM quality and quantity	Yes (By Infection Control (IC) department)	Yes (Daily check quality of wastewater)	Yes (By staff and the university)	Yes (By Env Team)	No Data	No

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
4. Have a responsible person/team	Yes (gardeners)	Yes (workers)	Yes (gardeners)	Yes (Env Team)	No	No
Outcome 1. Reducing use of chemical products	Yes (High)	No	Yes	Yes (High)	No	No
2. Volume use of EM (litre/year) (by interview)	About 2,400 litres	About 1,000 litres	Production: 3,600-4,800L ;Using: 960 – 1,200 L	About 800 litres	No Data (It is only a by-product.)	No
3. Cost reduction per year (by interview)	Producer: 400,000 B **(Discuss)**	No Data	About 33,600 – 42,000 B	More than 130,000 B	No	No
Summary	**Success (2nd)**	**Failure (Discuss)**	**Failure (Discuss)**	**Success (1st)**	**Failure (Discuss)**	**No Data**
Current Barrier:	- Insufficient communication and staff	No	- High cost. - Strong smell (interview)	No	No	No

5.10.2 Discussion

Note: the overproduction of EM in “C” will be discussed together with organic fertilizer in section 5.11.

According to FAO (2013, pp.14-15), there are another three formulas of EM production: (i) EM fermented organic matters to increase the microbial diversity of soil; (ii) EM fermented solutions to spray the plant to suppress pathogens and keep away insect pests; and (iii) EM fermented plant extract to supply nutrients to crops. This alternative agriculture was claimed to have gained attention worldwide, in order to replace chemical-based farming to more sustainable agriculture (FAO, 2013). EM is now produced in many countries and uses local inputs (EMSustains, 2015). For instance, EM fermentation can use kitchen waste (fruits, vegetables, foods, and meat). Thus, the limitation of adopting this concept is likely to be very low.

EM is produced and used in treating wastewater because: (i) an improved quality of wastewater is a criterion of HA; and (ii) EM is highly promoted according to the King’s SEP and GREEN and CLEAN concepts. Obviously, this practice’s performance by case hospitals is varied, because: (i) interest of responsible person (e.g. gardener – “A”); (ii) the Director’s encouragement (“C”); and (iii) both these factors (“D”). For instance, the variety of EM products in “A” was researched and developed by two gardeners.

The EM production of “A” has two problems as below. Firstly, totally different information was given by the Env Team and EM’s producers. The Env Team, which monitors all environmental progress, informed that EM has problems of strong smell and insufficient production. Additionally, it can save only 100,000 Baht a year. Both producers and many users agreed that EM products have high quality and sufficient quantity and this practice saves up to 400,000 Baht each year. This suggests low understanding and communication inside “A”. Secondly, EM production is the responsibility of only two persons, suggesting a lack of support and poor responsibility assignment. But “D” has good coordination between producers (pharmacist and nurses), users, and the Director. On that account, good coordination and support can be identified as successful implementation practices for EM practice.

Concluding Remarks

All public hospitals should produce EM from sour fruit waste. Pure EM liquid should be used to remove odour from wastewater treatment systems, and support its function. It is recommended to further produce EM products, particularly as high-quality sterilisation liquid to use with cleaning medical devices, linen and floors of the operating theatre. This can successfully decrease the expensive chemical products imported.

5.11 Organic Fertilizer

5.11.1 Analysis

Case hospitals know that organic fertilizer adds nutrients to the soil and assists plant growth without adverse effects. Thus, it has replaced chemical fertilizer. As presented in Table 5-11:

- “A” uses EM liquid.
- “C” uses dried sediment left from the cleaned wastewater, and its compost produced from leaf debris.
- “D” uses a compost produced from leaf debris, manure (from its pigs and cows), and biogas waste.
- “E” uses remaining waste from biogas production.
- “F” uses dried sediment left from the cleaned wastewater.

To increase the decomposition of leaf debris, producing fertilizer indoors and adding EM are very helpful, as stated by gardeners of “C” and “D”. The practices of “A”, “D”, “E”, “F” can be identified as the best, since they efficiently use their available waste/resources. In addition, these hospitals have never purchased fertilizer since starting this practice. The reason why “C” cannot be the best practitioner will be discussed after the table.

Table 5-11: Organic Fertilizer Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Produce own fertilizer	Yes (EM)	No (Plumber still tests dried sediment with plants)	Yes (Dried sediment and produce a compost)	Yes (Compost, EM, manures and biogas waste)	Yes (Biogas waste)	Yes (Dried sediment
2. Test quality of fertilizer in lab	Yes	Yes	Yes	Yes	Yes	Yes
3. Use produced fertilizer across the hospital	Yes	No	Yes	Yes	Yes	Yes
Outcome A volume of fertilizer produced and used per year	No Data	Not in use	-Compost: production (28,035 kg)/ using (10,238 kg) -Dried sediment: 40 racks	Never purchased fertilizer	Never purchased fertilizer	Never purchased fertilizer

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Summary	**Success**	**Failure**	**Failure (Discuss)**	**Success**	**Success**	**Success**
Current Barrier:	No	-This practice has not been reported to the Director	-Over production -Limited stock space for fertilizer	No	No	No

5.11.2 Discussion

(i) <u>Issues of "C" Hospital</u>

The question is: *'Why can "C", which has a large volume of produced EM and fertilizer, not be the best practitioner?'* It is a fraud issue, as follows:

The Director of "C" generally supports every green practice that has no cost or low cost, is effective and can increase eco-awareness. EM and organic fertilizer are two examples of low cost practices which reuse waste efficiently. EM is normally produced at about 3,600-4,800 litres a year. But the actual use is only 960-1,200 litres a year (or about 30%), because EM can be diluted before use. The rest of EM (about 3,000 litres – or 70%) is given to employees for their farming purposes. Moving to an organic fertilizer, 28,035 kg a year is produced; of which only 10,238 kg has been used by the hospital (or about 40%). The rest is donated to the local municipality.

Gardeners have to produce more EM and fertilizer than needed because a higher volume of production links with a greater chance to be promoted or gain a rise in salary. It is likely that the Director has not checked the actual volume use of EM and fertilizer; consequently the overproduction issue is not known yet. This insufficient monitoring may bring inappropriate assessment of work performance. Likewise, reducing the productions of both EM and fertilizer can save time and costs on hiring workers.

(i) <u>Issues of "E"</u>

"E" uses food waste left from biogas production as fertilizer across the hospital. Since this food waste fertilizer is sufficient, EM left from the biogas production is not used. Hence, this EM is always given to its personnel to use at home or with their farming. This is because these users know that EM is effective. It can be concluded that EM would be a good environmental policy for a hospital that really uses it effectively like "A" and "D".

(ii) <u>"B" Case</u>

One plumber from "B" has produced and tested compost from the dried sediment for two years. This is based on his interest in using resources effectively and bringing environmental benefits. This dried sediment has been used to effectively grow many pots of vegetable and herbs. Most of these plants were already booked by hospital people. Still, this practice is not implemented yet, because the plumber has never reported the success to the Director. It would probably reflect the top-down communication gap in this hospital. In contrast, any creative ideas of employees in “C”, “D” and “F” have often been informed their Directors. Therefore, the Director can provide sufficient support.

Concluding Remarks

All hospitals should produce their own organic fertilizer from resources available, including: (i) EM liquid; (ii) dried sediment left from the cleaned wastewater; (iii) a compost produced from leaf debris; (iv) animal manures; and (v) remaining waste from biogas production. However, the production volume should be consistent with actual need.

5.12 Linen

As in Chapter 3, linen such as patients' clothing, bed sheets, and towels have to be cleaned every day by the Laundry Department. Laundry workers collect used linen, which users (e.g. ward, clinic and laboratory) often sort into general and infectious types. Infected linen is washed in hot water (60-80C) while general linen uses cold water according to Infection Control Guidelines. After linen is dried at 90-100 C, the quality is assessed before wrapping, stocking and distributing.

5.12.1 Analysis

(i) <u>Linen Practices</u>

The MOPH standard requires public hospitals to stock six sets of linen compared with actual use volume (see Table 5-12). Obviously, only "C" can meet this standard, while "E" shows an extreme shortage with only two sets of linen. Accordingly, linen of "E" has been used and washed too often which shortens its lifetime, as mentioned by the Head of Laundry. Case hospitals use smaller washing machines for infected linen, because of lesser volume than general linen. This directly saves energy, water, and detergent for cleaning. "A" and "D" use their own EM washing detergent; while "F" uses organic softener that is diluted from concentrate. Thin linen (e.g. cloths and sterilisation wrap) and thick linen (e.g. blanket and bed sheet) are often dried separately. This saves electricity since drying thin linen needs 45 minutes, but thick linen may need two hours.

The wastewater discharged from using chemical detergent and softener can interrupt the wastewater treatment plant because it kills several beneficial microorganisms. As a result, the Head of Laundry will inform the plant when using new detergent or softener is used or the plant reports to the Laundry when it finds a problem from the Laundry's wastewater discharge. This on-going communication was mentioned by "A", "B", "D" and "F". All case hospitals, except "C", often fix or repair torn fabric by themselves.

Note that linen used for wrapping sets of sterilized medical devices should not be torn.

“B” and “D” often purchase fabric to produce, for example, cloths and sterilisation wraps. Producing own linen meets more hospital requirements and saves cost. Besides, since the Laundry of “B” has developed a specific cutting layout, thus it generates lower linen waste. But this is based on having sufficient human resources. In “C” and “F”, some children’s towels are produced from old linen. One interesting practice only adopted by “B” is that the Head of Laundry often discusses with users (e.g. wards). She needs the feedback for improvement, regarding: (i) cleanliness of linen; (ii) the need to fix linen; and (iii) sufficient volume of linen.

(ii) <u>Practice Outcomes</u>

Table 5-12 shows that “D” and “E” have not shown linen expenditure on their financial reports, so this hardly identifies their performance. Therefore, this study tries to identify the best practice based on the data obtained.

The findings indicated that “B” has the lowest cost of linen per bed of 1,181 Baht; while others’ linen are more than 3,000 Baht (see also Figure 5-12). What is more, the linen expenditure trend of “B” shows a reduction, from 39,234.15 Baht in 2010 to 9,600 Baht in 2011. From the interviews, “B” has purchased linen every two years, but others purchase linen several times a year. Because of this, practices at “B” are the best, including having sufficient linen, sorting and washing linen according to their types properly, on-going feedback from users and plumbers, making some types of linen and the Laundry making repairs.

Table 5-12: Linen Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Have sufficient linen (6 sets)	3-4 sets	4 sets	6 sets	3 sets	**2 sets**	4 sets
2. Record linen received and distributed	Yes	Yes	Yes	Yes	Yes	Yes
3. Sort infectious and general linen from source, and wash them separately	Yes	Yes	Yes	Yes	Yes	Yes
4. Have two sizes of washing machines, smaller size is for infectious linen	Yes	Yes	Yes	Yes	Yes	Yes
5. Use organic cleaning products	Yes (EM washing liquid)	No	No	Yes (EM washing liquid)	No	Yes (Organic softener – **save 10,200 B/yr**)
6. Dry thick linen (e.g. blanket) and thin linen (e.g. cloth) separately	Yes	No Data	Yes	Yes	Yes	No Data
7. Check the impact of wastewater	Yes	Yes	No Data	Yes	No Data	Yes

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
discharged from laundry on the wastewater treatment plant	(By Head of IC)	(By Head of Laundry)		(By Head of Laundry)		(By Head of Laundry)
8. Mending torn fabric/linen	Yes	Yes	No	Yes	Yes	Yes
9. Laundry buys fabric to make e.g. cloth, bed sheet, and Sterilisation wrap	No	Yes (Not for patient's cloth and gown)	No	Yes (Not for patient's cloth and gown – **save cost 30-40%**)	No	No Data
Other practice (Interview and observation)	No	- Discuss with users for feedback and improvement -Select a detergent with no impact on wastewater	-Make kid's towel from old blanket	-Washing and drying linen in sufficient volume	No	-Make kid's towel from old blanket -Washing and drying linen in sufficient volume

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
		treatment plant				
Outcome A volume use of linen	Increased (40.80%), cost per bed (3,176 Baht)	**Did not buy linen in 2013. Cost per bed of 2012 (<u>1,181 Baht</u>)**	Decreased (25.69%), cost per bed (4,169 Baht)	No Data	No Data	Increased (361.94%), cost per bed (5,173 Baht)
Summary	**Failure**	**<u>Success (1st)</u>**	**Success (2nd)**	**No Data**	**No Data**	**Failure**
<u>Current Barrier</u>:	-Fibres of old linen blocks up a washing machine	No	No	No	-Insufficient worker, linen, equipment and Administratio-n support	No

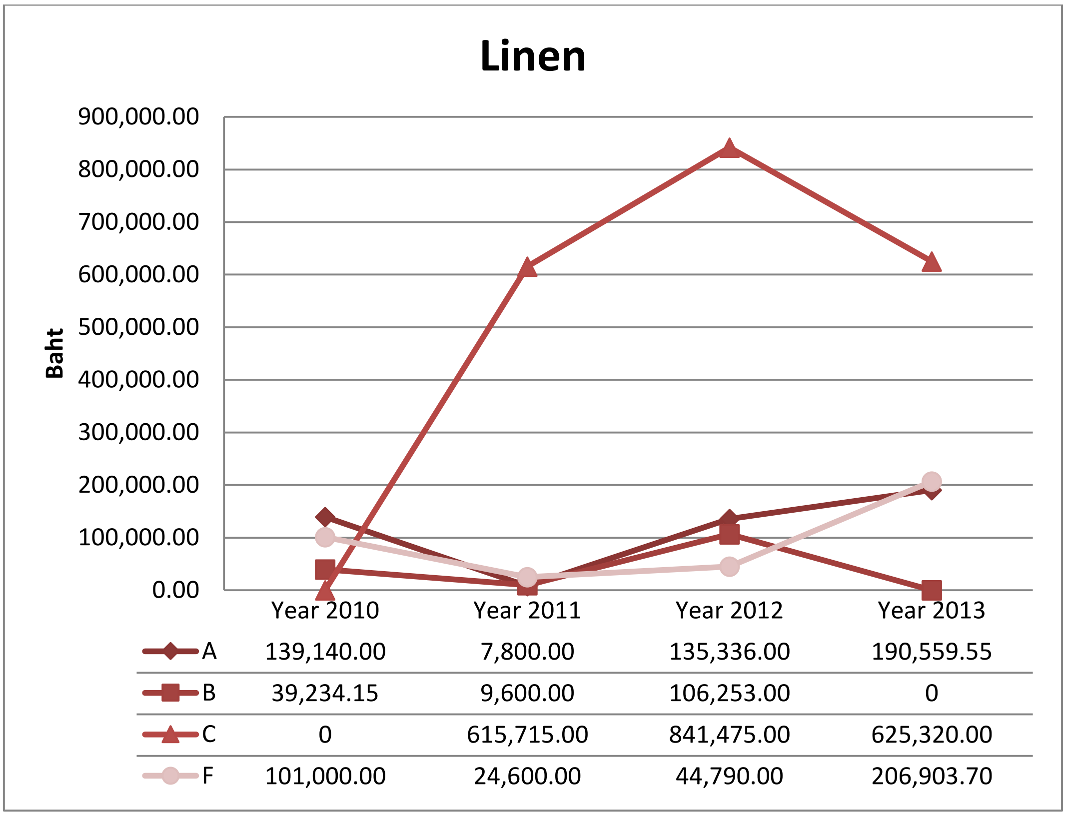


Figure 5-12: Expenditure graphs of water.

5.12.2 Discussion

(i) <u>Issues of Insufficient Linen</u>

Having inadequate linen means the same linen are washed and dried at high temperature too often, which directly shortens linen life (BC Textile Innovations Inc., 2010). Consequently, having 4-6 sets of linen is suggested by both the MOPH and Gajuryal (2014). “E” has only two sets of linen so that one set is with patients and another is being cleaned. The set with the patient is collected to be cleaned in the afternoon, and is used once again at night. That’s why linen of “E” is torn very fast and liable to shortages, as stated by the Head of Laundry. This is solved by repurchasing linen several times a year. This is not sustainable, owing to overconsuming linen, generating high linen waste, and growing purchasing and delivery. Respectively, “E” should consider allocating a larger budget to linen.

(ii) Organic Detergent and Softener

Organic detergent and softener do not impact linen's quality, wastewater treatment plant and people. Additionally, these products meet users' satisfaction (e.g., wards and central sterilisation supply) and increases cost saving. Therefore, "A" and "D" used their own-produced EM detergent. And "F" Laundry workers produce their own organic softener from concentrate. It is sold by the Bank for Agriculture and Agricultural Cooperatives (BAAC) that is promoting 'SEP'. The worker was inspired by visiting a sustainable learning centre, which is in her training program.

Note: Many Thai authorities have adopted and supported addressing SEP, for instance: (i) EM of the Electricity Generating Authority; and (ii) the organic softener and organic farming network of BAAC.

(iii) Laundry Issues

The laundry of "E" has appeared a problematic area, particularly the welfare of employees. The hospital cannot meet the sustainability goal, when overlooking this social pillar. The problems were stated by the Head of Laundry of "E" as below, which requires urgent help. Because of this, the hospital and maybe the government should pay close attention to improving the healthy workplace.

"E" with 528 beds has only four washing machines, while other case hospitals with less than 150 beds have 2-4 washing machines. Interestingly, four washing machines of "E" have been used for 19 years; although they were once sunk in the flood and frequently broken. For this reason, laundry workers have to wash dirty linen by hand in order to provide sufficient clean linen, and this 500-bed hospital has only 20 personnel. This problem has been reported to the administration several times, but there is no improvement.

Concluding Remarks

To extend linen's life and save use, the hospital should have sufficient linen (4-6 sets), use organic cleaning products, fix torn fabric/linen, and produce some of their own items. The most important practice recommended is receiving feedback from users (e.g., wards) to continue improving, for example linen's cleanness and sufficiency.

5.13 Office and Housework Supplies

There are many categories of: (i) office supplies (e.g. marker, highlighter, paper clips and cartridge); and, (ii) housework supplies (e.g. rubber gloves, waste bag and tissue paper). They are stored in general supply stock or office supply stock. Office and housework supplies are perceived as consumable resources; accordingly, they are the first reducing targets to improve the financial situation. Also, their reductions minimize waste and preserve natural resources.

5.13.1 Analysis

Several practices have been adopted to avoid overuse of supplies and expiration (see Table 5-13). Some supplies have a limited lifetime, such as a markers and highlighters that can dry up. The practices are varied, for example "B" and "C" examine users' stock for unused/old/expired items. From this examination, one officer of "C" found a large amount of dried markers and highlighters, due to excess resource requisition. Therefore, "C" established two policies: one is limiting resource requisition, and the another is setting 12 unrequested items (such as stationery, tissue paper and washing powder).

In all case hospitals, users have to purchase blue pens or pencils themselves. Other items such as printers, computers and correction pens are often in shared use. Particularly for computer supplies (e.g. toner cartridge, mouse and keyboard) that are high-priced, users have to show the old item when requesting the new one. "A" often considers patients' volumes, actual usage, and the development plan before approving the supply requisition. In reducing housework supply, "A" and "D" have used several types of EM cleaning products as mentioned earlier.

The Heads of Departments of "B" and "E" supervise their subordinates' behaviour in using supplies. Regarding sharp waste containers, a public hospital cannot afford these. Consequently, the hospital often reuses, for example, softener gallon containers and tin buckets as waste containers because they are strong and fully-closed. Lastly, hospitals often reuse old fabric as napkins and cleaning cloths, which can reduce the amount of tissue paper used.

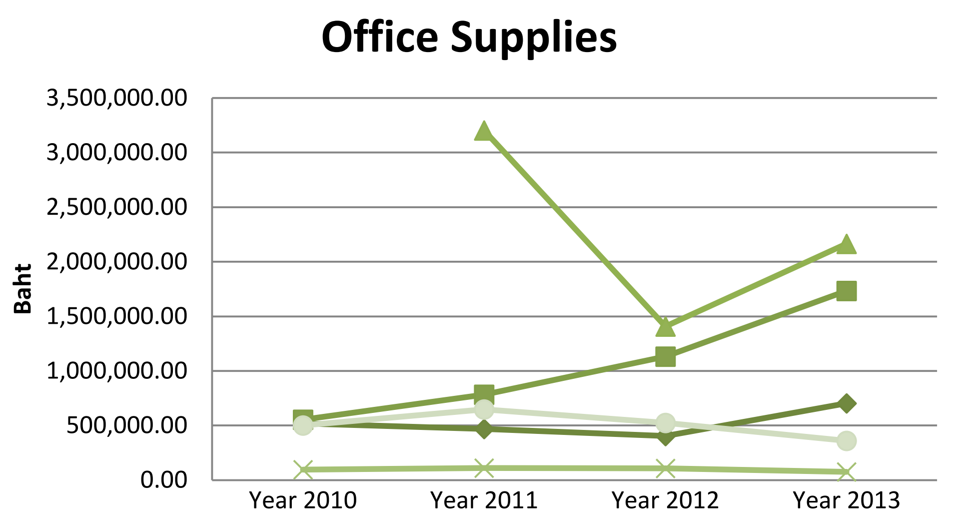
Table 5-13 shows the two best practitioners to be “D” and “F”. “D” has the lowest costs per bed of both office supplies (2,550 Baht) and housework supplies (2,529 Baht). “F” has the greatest reduction in amounts of office supplies (31.27%) and housework supplies (59.06%). Hence, their practices would be the best (see also Figure 5-13 and 5-14).

Table 5-13: Reducing Office and Housework Supplies Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Survey users' annual requirement on supply, approved by the Director	Yes	Yes	Yes	Yes	Yes	Yes
2. Check users' store for unused/old/expired items	No	Yes	Yes (Done by the committees)	No	No Data	Yes (Not often)
3. Sharing use of office supply	Yes	Yes (Low)	Yes	Yes	No Data	Yes
4. Compare data of stock volume with stock card and information system	Yes	Yes (Monthly)	Yes	Yes (Monthly)	Yes	Yes
5. Some items cannot be requested	Yes (Pen)	Yes (Pen and correction pen)	Yes (12 items e.g. tissue paper)	Yes	Yes (e.g. pen and pencil)	Yes (Pen and correction pen)
6. To request a new item have to show the old one	Yes	Yes	Yes (e.g. cartridge)	Yes	Yes (e.g. mouse, keyboard)	No Data
7. Reuse softener gallon container and tin bucket as a sharp waste bin	Yes	Yes	Yes	Yes	No Data	Yes

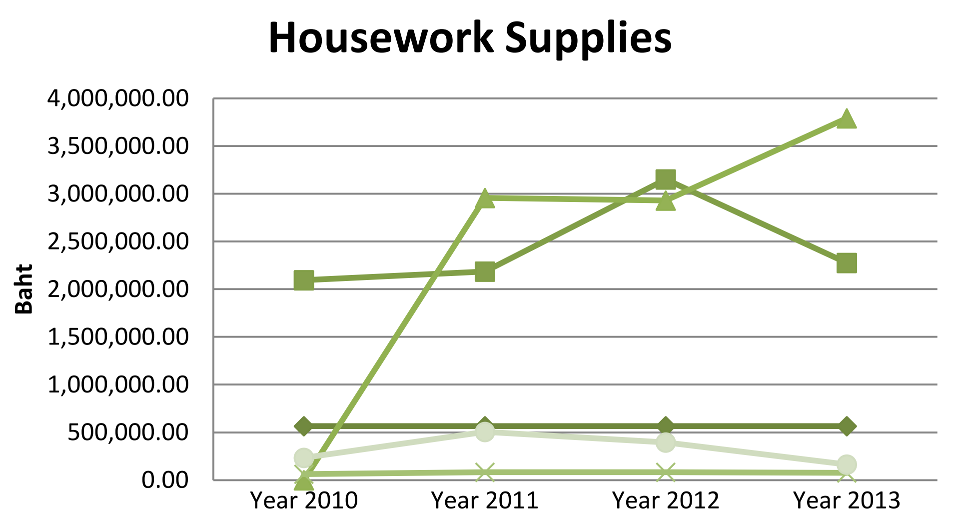
Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
8. Use old fabric as cleaning cloth and/or as toilet napkins	Yes (both)	Yes (Cleaning cloth)	Yes (both)	Yes (Cleaning cloth)	Yes (Cleaning cloth)	Yes (both)
9. Purchase supplies from local shop	Yes	Yes	Yes	Yes	Yes	Yes
Other practice	- Purchase as actual need, patient volume, and development plan	- Reduce stock's size - Buy in bulk - Heads monitor resource use	- Check historical data of requisition - Observe habit in using resource	- Request as actual need - Control use of cartridge, paper, and waste bag - Reduce stock's size	- Heads monitor resource use -Kitchen workers buy own knives	- Collect and reuse a paper clip - Produce organic fabric softener by Laundry
1st Outcome: A volume use of office supply	Increased (74.22%), cost per bed (11,716 B)	Increased (53.07%), cost per bed (19,249 B)	Increased (53.87%), cost per bed (14,442 B)	**Decreased (29.72%), cost per bed (2,550 B)**	Increasing consists with higher workload	**Decreased (31.27%) cost per bed (9,021 B).**
Summary	**Failure**	**Failure**	**Failure**	**Success (1st)**	**Failure**	**Success (2nd)**

Environmental Practice	**A (60 B)**	**B (90B)**	**C (150B)**	**D (30B)**	**E (528B)**	**F (40 B)**
						(Discuss)
2nd Outcome: A volume use of housework supply	Decreased (14.74%), cost per bed (9,406 B)	Decreased (27.70%), cost per bed (25,308 B)	Increased (29.40%), cost per bed (25,277 B)	**Decreased (7.90%), cost per bed (2,529 B)**	No Data	**Decreased (59.06%), cost per bed (4,040 B).**
Summary	**Success (3rd)**	**(Discuss)**	**Failure**	**Success (1st)**	**Failure**	**Success (2nd) (Discuss)**
Current Barriers:	No	-Overuse tissue paper	- Staffs do not reuse supplies e.g. paper clip	-Overuse tissue paper	- Increasing workload & department, -Overuse tissue paper	No



	Year 2010	Year 2011	Year 2012	Year 2013
A	517,716.91	469,343.75	403,469.68	702,942.26
B	552,683.99	783,209.23	1,131,722.10	1,732,375.81
C		3,203,557.74	1,407,861.04	2,166,267.60
D	95,120.18	109,683.62	108,876.57	76,516.12
F	500,030.84	646,354.10	525,017.32	360,841.11

Figure 5-13: Expenditure graph of office supplies.



	Year 2010	Year 2011	Year 2012	Year 2013
A	564,384.74	564,384.74	564,384.74	564,384.74
B	2,096,344.66	2,184,921.41	3,150,241.87	2,277,702.75
C	0	2,957,121.51	2,929,977.54	3,791,535.86
D	62,548.00	82,671.62	82,376.68	75,871.50
F	234,503.50	504,402.00	394,638.92	161,572.94

Figure 5-14: Expenditure graph of housework supplies.

5.13.2 Discussion

(i) Success Factors of "D"

As mentioned, "D" shows the lowest costs per bed of both office supplies and housework supplies; which are lower than others by between 2-10 times. Four main reasons are able to explain this, as follows.

Firstly, "D" has completed the HA assessment since 2012, which uses a lot of supplies both to prepare documents and clean-up workplace. This has led to reducing supplies in 2013. Secondly, the strategy of "D" focuses on reducing three key resources in terms of finance: cartridges, paper and waste bags (see paper in section 5.8). In addition, the Head of Office Supplies confirmed its success. Thirdly, to survive from a poor financial status increases both resource reduction and engagement. Lastly and most importantly, many housework supplies are replaced by EM's products (see EM in section 5.10). Only interviewees of "D" mentioned that they have already minimized resource use, until they cannot reduce it any further. This would reflect the successful implementation of the SEP in hospital culture.

(ii) Analyzing Practices of "F", "A" and "B" Hospitals

"F" shows the greatest reductions of office and housework resources by 30-60%. But, this is associated with downsizing its operation from 60 beds to 40 beds or 33%, and the reduction of allocated budgets. Due to this, it hardly shows that "F" is the best practitioner. One interesting practice of "F" is producing organic fabric softener, as pointed out in section 5.12.

From 2012 to 2013, the volumes of housework supplies of "A" and "B" have reduced by 15-28%; while their patients are increasing, particularly in "A" patient volumes have increased by 15-25%. This also would be the result of using various EM products in cleaning activities. It is seen that the changing volume of patients should have an impact on housework supplies rather than office supplies. This is because housework supplies are used in various cleaning activities.

Figure 5-14 shows that the volume use of housework supplies of "B" during 2012 is much higher than 2010, 2011 and 2013. As explained by the Director of

"B", it is the strategy to effectively spend all receiving budgets on supplies with a long lifetime, like housework supplies. As a result, there is no leftover budget to be returned to the government. Based on this evidence, the performance in reducing the housework supplies of "B" is not improving.

(iii) <u>Issues when Reusing Old Fabric</u>

Reusing old fabric as napkins can reduce tissue paper use. This tissue paper waste can be general waste or infectious waste depending on their sources, and often ends up in the landfill or being incinerated. Old fabric is also used as cleaning cloths, which reduces purchasing new cleaning cloths. But when cleaning these reused linen, its fibre often blocks up, for example, drain pumps and spin cycles of washing machines. This damages the machine, which interrupts the cleaning process and requires additional repairing. Besides, cleaning this reused linen requires extra resources, including detergent, softener, water, electricity and human resource.

Note that this study does not have strong evidence regarding linen's life cycle analysis. Therefore, it is difficult to conclude whether it is better to further reuse old linen as a napkin and cleaning cloth, or to buy new ones.

<u>Concluding Remarks</u>

To use office and housework supplies economically, the following practices are suggested: limiting volumes of resources requested, sharing use of resources, checking the users' store for unused/old/expired items, and reviewing and correcting user behaviour.

5.14 Water

5.14.1 Analysis

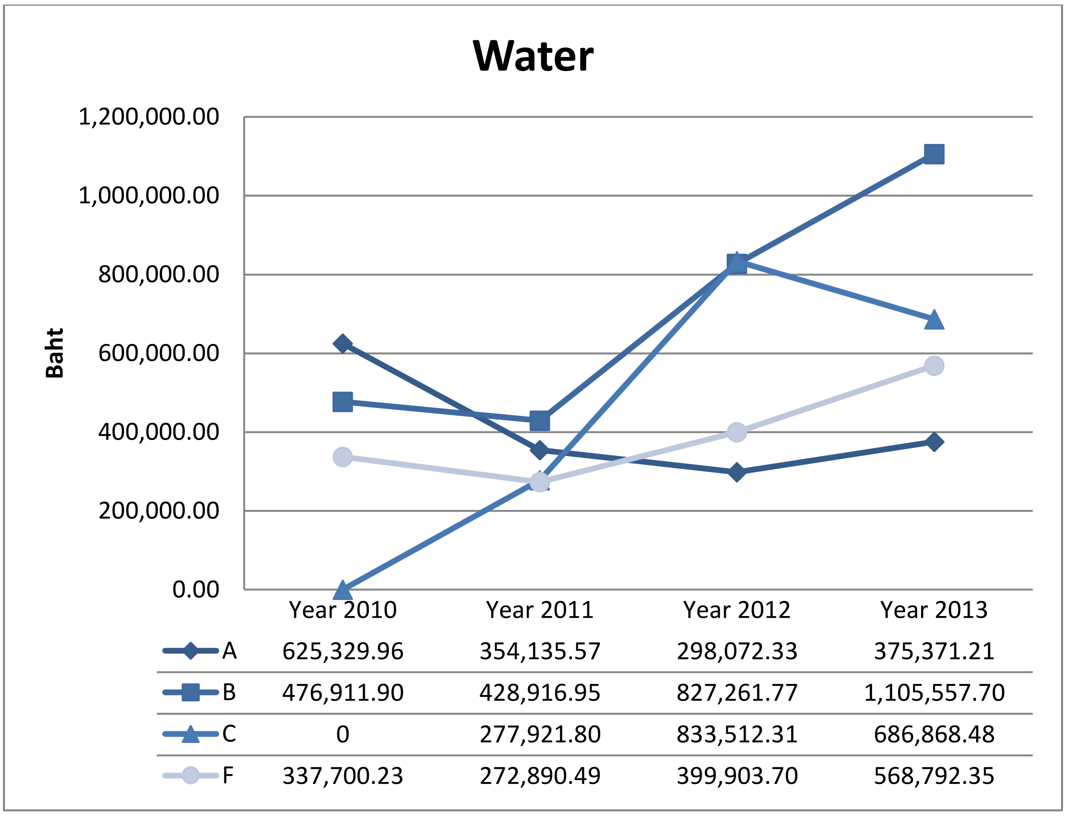
Some strong measures to conserve water, and monitor wastewater of onsite treatment plants were found as illustrated in Table 5-14. The Director of “C” has greatly promoted water-saving policy by measures such as turning off water after use, reusing the clean wastewater for watering plants, and installing water-efficient appliances (e.g. water-saving faucets and flushing toilets) across the hospital. As another example, “E” removes all water catchments of water dispensers; hence drinking water is used only as needed.

“C” has decreased water consumption by 17.59%, despite a new building being constructed and the volumes of patients increasing (see Figure 5-15). Likewise, it shows the lowest cost of water per bed, 4,760 Baht. For that reason, the above water-saving practices adopted by “C” can be recognised as the best. “A”’s performance is the second best. This is because water cost per bed is low (6,256 Baht). Although the volume of its water use is increasing (25.93%), this is consistent with increasing patients (18.64% - 20.88%) and the construction of the building.

Table 5-14: Reducing Water Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Practice of clean water	-Has a saving-water poster	No	- Use saving-water tools e.g. faucet and closet - Monitor water leakage	No	-Remove containers for water catchment, at water dispenser	-Has a water-saving poster - Water team monitors water usage
Practice of wastewater	- Monitor cleaned wastewater	- Monitor cleaned wastewater	- Monitor cleaned wastewater - Reuse wastewater for gardening	- Monitor cleaned wastewater	- Monitor cleaned wastewater	- Monitor cleaned wastewater
Outcome A volume use of water	Increased (25.93%), cost per bed (6,256 B)	Increased (33.64%), cost per bed (12,284 B)	**Decreased (17.59%), cost per bed (4,760 B)**	Volume use increased (74.5%)	No	Increased (15.11%), cost per bed (14,220 B)
Summary	**Success(2nd)**	**Failure**	**Success(1st)**	**Failure**	**Failure**	**Failure**

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B) (Discuss)	E (528B)	F (40 B)
<u>Current Barrier</u>:	No	-Old pipelines increases leakage -Halted using wastewater for gardening, since visitors used it.	-Unclear water-saving policy	-Unlimited use of ground water, since no cost apply	-Staffs do not report the water leak. - Not allow using wastewater for watering plant	- HA auditor halted using wastewater for gardening, due to unsafe hygiene.



	Year 2010	Year 2011	Year 2012	Year 2013
A	625,329.96	354,135.57	298,072.33	375,371.21
B	476,911.90	428,916.95	827,261.77	1,105,557.70
C	0	277,921.80	833,512.31	686,868.48
F	337,700.23	272,890.49	399,903.70	568,792.35

Figure 5-15: Expenditure graphs of water.

5.14.2 Discussion

(i) <u>Issues from Case Hospitals</u>

The success of “C” is driven by the Director, who is very interested in green technology. Before selecting and installing water-saving appliances, the hospital needed to conduct research and investment. This was done by the staff of “C”.

In “B”, its key barrier to saving water is old infrastructure (e.g. building and road) and pipelines. Due to the alignment of the pipeline under many old buildings, water leakage is hardly noticed. The hospital plans to restructure this old infrastructure, but insufficient budget leaves this problem unsolved as yet. Previously, “B” used cleaned wastewater for gardening. This practice was halted, because of having many problems, including patients and visitors using this water, wastewater not meeting the standard and the equipment being broken. In order to reuse wastewater for gardening, “C” set the time of watering plants (2-3 pm only), as well as tagging it as *‘water from a wastewater treatment plant, please do not drink or use’*.

In “E” the Head of Waste Management had discussed reusing wastewater with the administration, but the administration did not give permission because of the hygiene issue. Regarding “D”, in fact, it should be removed from this water section because “D” uses ground water that has no cost applied, and it has led to unlimited use of water. This unusual situation raises a question: *‘Does this behaviour reflect ineffective addressing of the SEP concept?’* (see also section 5.3).

(ii) <u>Rain Water, Treated Wastewater and Grey Water</u>

As Thailand is a tropical country “A”, “B”, “E” and “F” use a large volume of tap water for gardening, which generates high expenditure. The hospitals could grow more drought-resistant plants, and add more organic compost or bark to retain soil moisture. Another solution is collecting rainwater to use for, for example, watering plants, washing, vehicles, flushing toilets and cooling. Only “C” has reused clean wastewater for watering plants. Still, the quality of treated wastewater is questioned.

The WHO suggested reusing treated wastewater for non-consumption purposes. But this treated wastewater should contain no more than one helminthes egg per litre and no more than 1,000 faecal coliforms per 100 ml (Prüss et al., 1999, p.132). To support this practice, the Thai government should develop guidelines on reusing wastewater, such as the number of times to reuse water, and reclaimed water quality. What is more, both design and equipment to supply wastewater should be provided. Greywater from the kitchen, washing (only general linen) and baths should be collected and used for toilet flushing (The Renewable Energy Centre, 2013). Generally, this needs installing extra equipment to pump and collect greywater.

<u>Concluding Remarks</u>

To increase saving water, the hospital should turn off water after use, reuse the clean wastewater for watering plants, and install water-efficient appliances (e.g. such as water-saving faucets and flushing toilets) across the hospital. Additionally, the volume of water used should be frequently reviewed for action taken.

5.15 Equipment

The Thai hospital accounting system has classified resources into two major categories: (i) equipment and tools that have a lifetime of more than one year; and (ii) consumable supplies that have lifetimes less than or equal to one year. This section discusses only the first category: medical and office equipment. However, medical tools have already been presented in section 5.3.

Note: Since the actual buildings were not included in the key research area, hence their maintenance costs are not focused on in this section.

5.15.1 Analysis

A Head of Maintenance of “A” explained that the growing volume of patients and equipment generally raises the volume and frequency of maintenance. Fixing or maintaining can be processed at the source of the equipment or by the Maintenance Department. A requisition for maintenance is done by submitting a paper form, telephone call (urgent case), and online system (see Table 5-15).

Next, the technician often ranks the urgency of fixing and completes the task. For instance, the technician must fix an electric generator before a light bulb or computer. This is because the broken generator affects the operation of all electrical devices, particularly the devices used constantly in the intensive care unit (ICU). Generally, hospital employees are trained by vendors and the MOPH about using and providing primary care of medical equipment. Additionally, vendors often provide the maintenance of their products every 6 months, and change spare parts every 1.5-2 years.

A Head of Laboratory of “C” stated that proper maintenance of laboratory machinery can reduce chemical solutions used in lab tests. This is owing to the machine needing to be tested on a daily basis, by using, for example, a blood sample or ‘chemical solutions’. If the machine is irregularly checked, it needs to be tested several times to meet the standard result. This increases the use of chemical solutions that are very expensive and wastewater discharged.

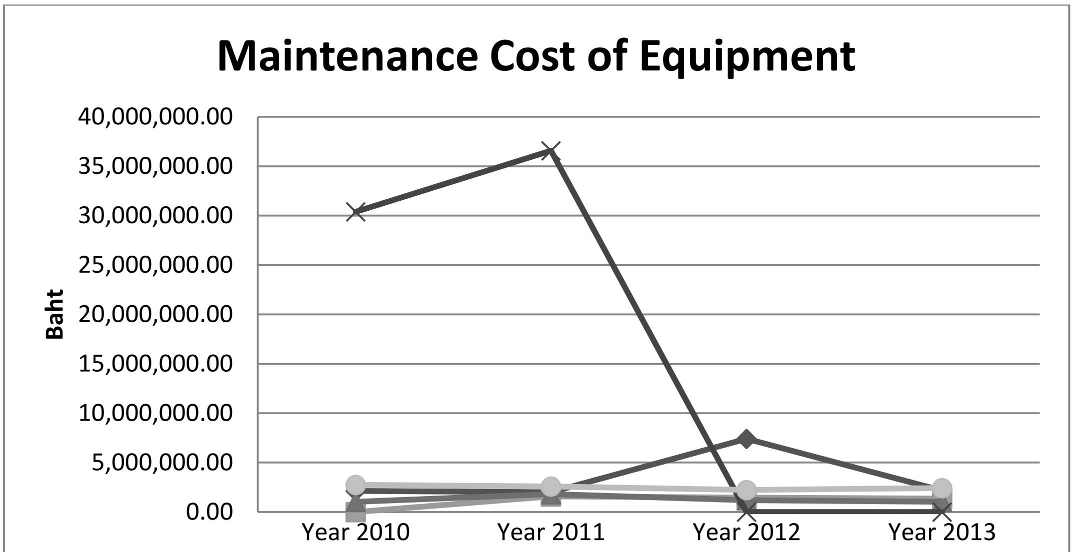
Using an online system to receive requests for maintenance has been applied by “B”, “C”, “E” and “F”. This system supports: (i) fast maintenance/repairing that extends the life of equipment; and (ii) the decision to purchase new items by tracing historical data (e.g. life time and frequency of fixing). All employees of "F" are responsible for taking primary care of hospital equipment. For instance, a nurse on a ward will frequently clean the air conditioner filter; which was previously done by a technician. "F" has stored unused equipment such as tables and chairs in the central warehouse, so that users can take items needed to use at their work places. This reduces purchasing new items and effectively uses resources.

Even though "F" has adopted several practices, its maintenance cost is the highest (60,255 Baht per bed), or about seven times higher than "C" (see Figure 5-16). "C" has the lowest cost of maintenance per bed (8,993 Baht); while "B" shows the greatest cost reduction of 70.62%. To identify best practice in this case is very difficult, which will be explained in the discussions.

Table 5-15: Equipment Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Collect good spare parts for reusing in further fixing	Not Mentioned	Not Mentioned	Yes (Has a store)	Not Mentioned	Yes (Has a store)	Yes (Has a store)
2. Provide regular calibration or maintenance	Yes	Yes	Yes	Yes (Has a list of maintenance)	Yes (Has a list of maintenance)	Yes
3. Rank the urgency of fixing	Yes	Yes	Yes	Yes	Yes	Yes
4. Exchange unused equipment among users	No	No	Yes (every quarter)	Yes (e.g. tables and chairs)	No	Yes (Has a store for this item)
5. Submit requests for fixing online	No (Paper)	Yes (Himpro)	Yes (HOSXP)	No (Paper)	Yes (RMC 2013)	Yes (RMC 2012)
6. Discharge old/broken equipment from the list according to regulation	Yes	Yes	Yes	Yes	Yes	Yes
7. Other practice	No	No	No	No	No	-Staff can provide primary care of equipment

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Outcome Amount of maintenance cost	No Data	Decreased (70.62%), cost per bed (24,150 B)	**Decreased (7.22%), cost per bed (8,993 B)**	Decreased (14.04%), cost per bed (34,135 B)	No Data	Increased (8.54%), cost per bed (60,255 B)
Summary	**No Data**	**(Discuss)**	**Success (1st)**	**Success (2nd)**	**No**	**Failure**
Current Barrier:	No	No	No	No	Insufficient technician	No



	Year 2010	Year 2011	Year 2012	Year 2013
B	2,129,715.00	1,994,384.00	7,397,500.00	2,173,513.00
C	0	1,584,995.00	1,453,935.30	1,349,009.00
D	1,033,180.00	1,820,538.37	1,191,380.50	1,024,058.48
E	30,398,630.89	36,580,678.21	0	0
F	2,756,154.35	2,602,925.16	2,220,575.43	2,410,187.69

Figure 5-16: Expenditure graphs of maintenance.

5.15.2 Discussion

(i) <u>Issues of “B” and “F” Hospitals</u>

It is seen that the hospitals conduct regular maintenance and calibration as enforced by the MOPH. Their sizes have not really been enlarged during 2010-2013 (the focus period). This has brought minor changes in equipment volume and maintenance costs.

In “B” its maintenance costs of equipment between 2010 and 2013 are 2.13, 1.99, 7.40 and 2.17 million Baht, respectively. Visibly, the maintenance cost of 2012 is much higher than others, because of operating a large building maintenance project. For this reason, the hospital shows the greatest cost reduction in 2013, of 70.62%. Normally, the maintenance costs of buildings and equipment should be separately reported, in order to reflect their actual expenditure. But “B” and “F” have combined them. This is one reason why the maintenance cost of “F” is really high. Evidently, it shows high inconsistency in manipulating financial reporting among Thai public hospitals, which increases difficulty in understanding and analyzing them. In consequence, a structural reporting system is needed. F" has the highest maintenance cost of 60,255 Baht/bed, which is a consistent trend (see Figure 5-16). The Director is quite worried about high cost issues (e.g. cost of outpatients per visit), these are much higher than nearby district hospitals. The further interview with its accountant revealed that she does not have a good understanding of the new government costing system (e.g. the classifications of direct and indirect costs). and this might lead to incorrect figures in the financial report, as the interview suggested. However, the hospital does not have sufficient budget to hire a proficient cost accountant to solve this problem. From the explanations of "F" and "B", it can be concluded that "C" would be the best practitioner in managing equipment.

(ii) The Discarding of Old Equipment

Much equipment of the hospital is electric or electronic types, which requires special treatment as hazardous waste (Tangpaitoon, 2012, PCD, 2013b). But, the waste equipment is not properly managed by certified third parties. This is because a very small number of manufacturers provide take-back programmes, and there is insufficient government support. Old equipment has to be firstly approved by the Provincial Health Office before formally discarding. Generally, the approval process takes more than one or two years, leading to a large volume of old equipment being stored in the limited space of a hospital. This is disrupts internal transportation and space use, as reported by interviewees. After that, for the purpose of transparency, the hospital must organize an auction to formally dispose of this old equipment. The bidders can be either hospital employees or external parties like recycling shops. For that reason, proper waste management is hardly to be expected.

Concluding Remarks

Minimizing use of equipment should focus on frequent maintenance or calibration, which generally extends its lifetime. This is supplemented by practices such as reusing good spare parts, sharing use of equipment, fast maintenance (by e.g. online maintenance requisition), and providing primary care of equipment by staff (e.g. cleaning the filters of air conditioning).

5.16 Other Green Practices

5.16.1 Analysis

From Table 5-16, case hospitals increase green areas by having more small gardens (flowers, vegetables, fruit trees, etc.), although they have construction works and limited space. The green zone of “D” can absorb 394,200 $kgCO_2$/year as well as generate 262,800 kgO_2/year.

Regarding the reduction of plastic and foam containers, two key strategies have been employed; one is giving a cloth bag to long-term patients, and another is banning the use of plastic and foam food containers. Cloth bags have been used by “A”, “B”, “C”, “D” and “F”, but only “C”’s practice is successful. This is owing to all departments helping remind patients to use their given bag for carrying, for example, medical records, medicines dispensed for 3-4 months, and injections.

Only “C” and “D” claimed that they are 100% free of plastic and foam food containers in both kitchen and canteen. The supporting strategy for this is reusing supplies, especially kitchenware and medical devices. Purchasing green products, particularly medical supplies, is rarely adopted because of the limited number of green suppliers in Thailand and the high cost. In addition, joint-purchasing limits selecting green products. This is due to the decisions being made by the Directors’ meeting, which may focus on cost rather than environmental issues. Lastly, very small amounts of supplies are reproduced or donated. Only “C” has a clothing bank for giving to poor patients and visitors.

Table 5-16: Other Green Practices and Outcomes.

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
1. Have more plants and gardens (to increase oxygen)	Yes (Fruit farm)	Yes (Many small gardens)	Yes (1 staff takes care of 1 tree)	Yes (All adjust soil and grow plants)	Yes (1 staff takes care of 1 tree)	Yes (Grow yellow palm, it emits high oxygen)
Outcome	**Failure**	**Success** (Many gardens)	**Success** (Many gardens and big trees)	**Success** Absorb 394,200 kg CO_2/year, give 262,800 kgO_2/year	**Failure**	**Success** (Many plants)
Current Barrier:	-Construction -Insufficient time, budget, resource, and Director's support	-Construction -Limited space	-Construction -Limited space	No	-Recover from flood -Construction -Limited space	-Limited space

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
2. Use a cloth bag with long-term patients	Yes	Yes	Yes (Staff remind patients using given bag)	Yes	No	Yes
Outcome	**Failure**	**Failure** (Patients do not use it.)	**<u>Success</u>** (Reduce use of plastic bags)	**Failure** (Patients do not use it.)	No	**Failure** (Patients do not use it.)
3. Reuse kitchen food containers and metal medical devices	Yes	Yes	Yes	Yes	Yes	Yes
Outcome	**<u>Success</u>**	**<u>Success</u>**	**<u>Success</u>**	**<u>Success</u>**	**<u>Success</u>**	**<u>Success</u>**
4. Reduce using plastic and foam food containers in the “canteen”	Yes -Cassava containers (said by Env Team**)**	No	Yes -Offer a discount if brings own container	Yes - e.g. banana leaves	No	No

Environmental Practice	A (60 B)	B (90B)	C (150B)	D (30B)	E (528B)	F (40 B)
Outcome	**Failure** Observation found foam containers	**No**	**Success** -Free of plastic and foam food containers	**Success** -Free of plastic and foam food containers	**No**	**No**
5. Other green strategies	- Ward makes kidney bowl from plastic bottle	- Has a green knowledge zone	- Have a clothing bank - Use bergamot in cleaning e.g. restrooms - Organize second hand market in the hospital	- Use bergamot in cleaning e.g. restrooms - Use earthworms to decompose waste	- Make a book shelf from old refrigerator	No

5.16.2 Discussion

Although increasing the green area is one criterion of HA, it is mostly driven by the interests of the Directors. For “C” and “F”, their Directors have focused on reducing global warming, so these hospitals have many small gardens and big trees. Yet, some practices are motivated by knowledgeable employees. Fruit gardens of “A” are also driven by its workers. But, this practice is hard to continue since the hospital needs the space for construction. Another practice adopted is that the Head of Ward of “A” has recycled plastic bottles as kidney bowls. They are disposed of after use, reducing plastic waste and cleaning supplies. This Head also uses a leaning shelf for medical stock to support the FIFO system. Hence, when an old item in the front is picked, it is automatically replaced by the new item behind.

With regard to cloth bags, they can be reused several times within 2-3 years. This can decrease the volume of large plastic bags (e.g. one bag for chronic medicine, one bag for syringe); which generally end up in landfills and hardly decompose (West, 2015). Regarding foam food containers or styrene containers, these are associated with polystyrene which is dangerous to health (Earth Resource Foundation, 2015). It is difficult to recycle, which goes against the concept of a close-loop of product. As a result, using reusable food containers is very beneficial for health and environment.

Concluding Remarks

Several important practices should be established, including: (i) increasing green areas to absorb more CO_2; (ii) giving a cloth bag to long-term patients to collect their medicines and medical supplies (all staff should remind patients to use their given bag); (iii) banning use of foam and plastic containers; and (iv) creating a clothing bank.

Chapter 6: Recommendations and Conclusions

6.1 Introduction

6.1.1 How the research aim was addressed?

The aim of this research was:

'To identify Green Logistics best practice leading to the efficient management of resources and waste in Thailand's public hospitals'.

The results of this study were presented in Chapter 5 and highlight the most effective practices to be adopted in tackling the overuse of resources, mismanagement of waste, and financial crises (see Tables 6-1, 6-2; and sections 6.2-6.2). It considers hospital type, size, resource, budget and impacts; supplemented by cautions, tips and governmental roles. The discussion offers guidance to practitioners to assist with decisions such as the selection of appropriate green logistics practices implementing them based on operational needs/capabilities; the phasing in or breakthrough adoption of practice or organisational restructuring in order to , follow a sufficiency economy philosophy (SEP).

Note: since recommendations are key purpose of this chapter, therefore there is no further analyses or discussions. (All analyses and discussions can be found in Chapter 5).

6.1.2 How the research questions were addressed?

As in Chapter 4, this research contains 5 research questions. They were addressed as follows.

1. **What are the most important study areas in Thai public hospitals?**

The most important study areas were pointed out in Chapter 4, section 4.2 (ii) key study areas, covering both physical elements (main resources/waste, and logistics functions), human elements (all rankings and human factors).

2. **How to measure the green logistics performance of Thai public hospitals, in the areas identified in 1?**

The GL indicators were developed as presented in Chapter 4, section 4.3 research indicators (see also Appendix 5), and used to measure case hospital performance as in ‘Chapter 5, section 5.3 – 5.16’.

3. **Which Hospitals are performing best on each measure?**

The hospital personnel were interviewed about their establishment and operation of environmental programmes, supported by reviewing related documents and observations. These are in Chapter 4, sections 4.4.1 – 4.4.3. Ways to identify best practices was shown in section 4.6, and the best practice hospitals on each measure were revealed as in Chapter 5.

4. **What practices are allowing them to perform best?**

The green practices (both physical and implementation practices) were investigated from their establishment to outcomes and future directions; by (i) interviewing personnel, (ii) reviewing hospital documents, and (iii) observing the practices (in Chapter 4, section 4.4). The outcomes of observation were shown in Chapter 5.

5. **What are the barriers to addressing environmental programmes in Thai public hospitals?**

The barriers were identified when visiting case hospital, and can be classified into (i) barriers to addressing the overall green program, and (ii) barriers to addressing green practice. These barriers and ways to overcoming barriers were presented in Chapter 5, data analyses and discussions.

Obviously, we can find the best physical practices as well as best implementation practices as presented in Chapter 5. However, we cannot find the best hospitals from the green logistics perspective, because one hospital adopts several practices, which there performances are varied.

For example, Hospital “D” that has applied SEP concept performs very well in many practices, except ‘water practice’, which water is overused because there is no charge. Therefore, “D” cannot be the best hospital.

6.2 Recommendations for Effective Physical Practices

The proposed recommendations centre on eight key environmental aspects and associated practices comprising: (i) medicine and medical supplies; (ii) electricity; (iii) energy (biogas); (iv) infectious waste; (v) recyclable waste; (vi) paper; (vii) effective microorganisms (EM); and (viii) organic foods. The ranking priority of practices as listed here is consistent with their importance to medical care, the environment and financial status/impact.

Since each hospital is unique, so the hospital should consider their specific features (such as budget, time frame, size, and human resource), in order to select practices that suit them the most. These concerns and the applicability of practices recommended can be found in both sections 6.2 and 6.5.

Note: the statistical data, such as carbon and waste reductions from adopting the above practices can be found in Chapter 5 and Appendix 10.

6.2.1 Medicine and Medical Supplies

Medicine and medical supplies are very important to medical treatment, and account for more than half of the total budget. Poor management of such products increases waste that is hazardous and requires special disposal systems increasing overall cost expenditure. The medical resources practices listed below can improve patient health, lower the number of hospital visits, reduce unused and wasted medicine, and command better control of stock.

1st Recommendation

Long-term medicines should be dispensed for only 1 month (rather than 3-4 months as previously). This will reduce the overall cost of medicines supply and waste. Patients are contacted more frequently for follow-up to discuss medicines use and review.

Conditions Required:

- ✓ All healthcare professions, particularly physicians, should be well-trained about reducing prescribing of medicine.
- ✓ This must be supported by developing/adjusting the national standard practice in prescribing medicine. And, the guidelines should be available online.
- ✓ Effective communication and discussion should be addressed in the hospital, in order to increase understanding among stock controllers (e.g. pharmacy and lab), and users (physicians).
- ✓ Dispensing medicine for 1 month instead of 3-5 months as previously generally increases patient visits. This brings difficulty in transportation for patients who are poor, or patients who live in rural areas where the transport is poor.

2nd Recommendation

The hospitals should adopt returned medicine programmes. The benefits are not only reducing the volume of medicine use, checking medicine use of patients, and following-up prescribing medicine by physicians. It also increases safe disposal.

Condition Required:

- ✓ The hospital has to spend more time and human resources on close inspection of medicine returned.

3rd Recommendation

In effectively reducing medicine, the hospital should increase use of herbal medicines and Thai traditional medicine treatment.

Condition Required:

- ✓ The hospitals should produce their own herbal products, or produce the herbal products from inputs made locally, or purchase them from nearby hospitals (see section 6.2.8).

4th Recommendation

The hospital should select using more 'multiple-use' medical devices especially glass and metal devices, rather than increasingly using single-use ones. In cleaning the used devices, own-produced EM sterilisation liquid should be considered.

Condition Required:

- ✓ The government policy, statement: 'increase use of single-use medical devices', should be replaced by 'increasing use of multiple-use medical devices' and 'improved sterilisation process and quality assessment (QA)'. This is owing to single-use devices being expensive and mostly needing to be imported, and generating greater waste volume.
- ✓ The study revealed that all case hospitals have reused single-use medical devices (e.g. plastic oxygen tubes and plastic urine containers). Their quality deteriorates after passing sterilisation process. Thus, the government should more strictly control this activity.

5th Recommendation

The hospital should establish a sustainable health system that integrates patients, staff, and community. Lifestyle advice should be given, regarding exercise, smoking, sleeping, diet and consumption, and practising mindfulness. Staff are encouraged to practice mindfulness with patients and observe their blood pressure for beneficial effects. This should be supported by having organic foods.

Condition Required:

- ✓ The focus needs to change from perceiving the patient as a customer that only provides a financial return and adopt a more person-centred perception of the patient as a valued individual. Correspondingly, better care and a more holistic service are provided.

Tip:

- Education on sustainable health and self-medication can be delivered at the hospital, community, school and temple, which strengthens the health of all Thai people.

6.2.2 Electricity

It is recommended that all public hospitals implement the 'hardware-systemware-peopleware' (HW/SW/PW) concept, to effectively reduce electricity usage. In order for this concept to be effective, the entire organization must be restructured, regarding policy, peoples' attitudes and behaviour, and technology as below.

- **Hardware Practices**

The findings of the study indicated that the air conditioning system accounted for up to 60%-65% of the total electricity cost, and this usage was found to be excessive compared to actual need. As a result, this is the key area that should be targeted and usage reduced by:

<u>6th Recommendation</u>

All air conditioning systems should be set at 26-27C, and use the highest fan speed. This practice is more effective than using 25C with low or medium fan speed. It provides the same comfortable atmosphere, and cuts more electricity and cost.

Tip:

- To increase saving electricity, all air conditioners should be maintained regularly. The minor maintenance, particularly cleaning filters, should be done by well-trained staff in that department (e.g. nurses).

<u>7th Recommendation</u>

The large areas, like canteens and OPDs, should promote a good air ventilation system rather than using more air conditioners. It is an effective strategy for both electricity reduction and infection and disease control (e.g. flu, asthma, and respiratory problems) (HCWH, 2011, p.30). Measures such as raising the roof, installing water evaporation systems, and adding a fresh air intake should be used.

Condition Required:

- ✓ The policy of 'Sustainable Building Design' should be mandated when constructing a new building or renovating an old building of the hospital. Accordingly, the design is more in line with the principles of natural ventilation rather than relying on air conditioning systems.

Tip:

- ➢ Wherever possible, use trees or other garden features to promote shade and using misting fans can lower the temperature.

8th Recommendation

There are additional effective practices to save electricity use, including using pull-switch lighting, setting times of using the appliances, installing energy-saving appliances, and walking up stairs instead of using the elevator.

- **Systemware Practices**

Systemware refers to putting a structure in place that allows people to make evidence-based decisions. Therefore, a clear goal, policy, structure and application should be addressed.

9th Recommendation

Every hospital must have a written strategy for resource and energy consumption reduction. The strategy must at least comply with the minimum requirements set by the Ministry of Energy. This should form part of the HA process and no hospital can achieve HA without a credible strategy.

Condition Required:

- ✓ The minimum requirements should be developed for all types of hospital (e.g. district, city, central and university hospitals).

10th Recommendation

Each building should have a meter for electricity and appropriate measures for other key resources. This allows targets to be set and monitored by departments. Any areas that can be identified as significant users of a particular resource, e.g. electricity, should have their own meter/monitoring system.

Conditions Required:

- ✓ The government should allow separating meters of each hospital and its construction work, to effectively measure actual usage.
- ✓ In installing more meters at key buildings/areas, the government should provide support in the form of both technicians and meters.

11th Recommendation

All hospitals should be required to define units of analysis they use to measure and reduce electricity, e.g. the standard ones being kilowatt, CO_2 reduction, and Baht.

Condition Required:

- ✓ The government should provide: (i) the unit of measurement; (ii) the recording system; and (iii) the analysis method.

- **Peopleware Practices**

People are the most crucial success factor. Based on the findings and supporting literature, there are three key practices to establish an energy-saving culture, which persist even if there is a change.

12th Recommendation

There should be a training programme in place for all team members which must at least comply with the minimum requirements set by the government. The study visit is highly suggested, because it increases understanding and adjusts attitudes through observation and participation in green activities provided by the study sites.

13th Recommendation

All hospitals should create an integrated energy-saving team, which comprises of members from all departments. Regular team meetings must take place to monitor progress against current plans and to develop ongoing programmes of improvement.

14th Recommendation

A formal report on progress and future plans to support GL strategy must be prepared each year and presented to the annual general meeting (AGM). This will reinforce and stimulate GL activity. In addition, these reports will form part of all future HA documentation.

6.2.3 Energy – Biogas Production

15th Recommendation

All hospitals that have sufficient food waste or manure should produce biogas, in order to replace use of kitchen LPG. Therefore, biogas plants must be established. This practice is suitable for both rural and city hospitals, and it uses a small space for gas production.

Condition Required:

- ✓ The biogas plant may need high investment: (i) the biogas plant for a large hospital may invest 0.5-1 million Baht; and (ii) the blanket plant for small-sized hospital may invest less than 0.4-0.5 million Baht. It also requires knowledge in operations and maintenance. For that reason the government should provide sufficient support.

Tip:

- There are two key wastes of biogas: one is EM liquid which can be used with cleaning and wastewater treatment plants; another is solid waste which is an effective fertilizer.

16th Recommendation

The hospital strategy should ensure having sufficient feedstock. It should be locally obtained from the hospital itself or nearby markets to reduce transportation. Other materials that can be used in biogas production are human manure, wastewater and plant materials, as stated by Gerlach et al. (2013) and Ministry of Energy (2012).

17th Recommendation

The hospital should install more efficient equipment for biogas to increase pressure, such as using improved pressure pumps and generation compressors. Special modifications of stoves, ovens and burners which may improve combustion and the efficient use of energy are recommended.

Condition Required:

- ✓ The government should research improving biogas pressure, and offer low-priced and efficient equipment.

6.2.4 Infectious Waste and Sharps

Infectious waste (IW) management is ensuring the smallest IW volume generated; the practices highlight increasing the accuracy of waste sorted.

18th Recommendation

All hospitals should embed effective and regular monitoring systems. This should be the responsibility of all Heads of Departments as well as the

Environmental Team. Moreover, it includes instigating proper corrective measures if policy and practice are not adopted and followed.

<u>19th Recommendation</u>

Checking the accuracy of waste collected and sorted should be done on a regular basis. All waste bags should be tagged at source, to facilitate checking and provide feedback for action or reward.

Tip:

- Undertaking selective waste bag checks, can save time (as opposed to 100% checking of all waste bags) and can ensure that the waste segregation process/practice is appropriately adopted across the hospital.

<u>20th Recommendation</u>

Patients and visitors, particularly in wards, should be included in the hospital waste segregation programme. This is because long stay inpatients and their relatives can over a period of time become less vigilant and dispose of their waste incorrectly. Likewise, the results indicated that wards appear to be the largest IW generators because they have the largest footfall (patients, visitors and staff).

Tips:

- In the rural areas of Thailand, patients and relatives are sometimes illiterate, and have not heard about waste segregation or environmental impact. Subsequently, more education is needed by using signage instead of letters. Once visitors learn the correct sorting and disposal practice from the hospital, they can apply this to their homes and community. This is an indirect and extended beneficial outcome of applying SEP in hospitals.

6.2.5 Recyclable Waste

Recycling waste management makes certain that recyclable waste is sorted and managed in the most environmentally friendly and economical way. As identified in this study, all public hospitals should decide who should sell waste and how should revenue generated be distributed. Two recommendations below are suitable for hospitals of all sizes.

<u>21st Recommendation</u>

For the hospital with a small amount of recyclable waste, allowing departments or housekeeping workers to sell this waste is more effective than establishing a bank.

Tip:

- ➢ Waste should be sorted into the basic categories of cardboard, paper, plastic bottles and glass bottles as a matter of best practice and for ease of disposal/resale.

<u>22nd Recommendation</u>

For the hospital with a large amount of recyclable waste, establishing a recycling bank is very effective in returning financial benefits to the hospital for development and employee's bonus. A recycling bank should:

- Sort waste according to selling prices,
- Have a waste storage room that stores each waste type separately,
- Have a bank controller,
- Have a systematic recording system of waste collected and revenues, and,
- Have a clear revenue allocation system.

Downside:

- ❖ In changing from selling waste by employees to a formal recycling bank, the study found that clear communication, encouragement, and a penalty system are ineffective for change, because employees try to retain the financial benefits.

Conditions Required:

- ✓ Whilst this is an effective mechanism for revenue generation (if the scale warrants it), it will increase the manpower and resources required for this area.
- ✓ The government should include a recycling bank in HA, as well as develop a clear selling revenue allocation to reduce internal conflict regarding financial benefits.

6.2.6 Saving Paper

To save paper, the hospital should work around: (i) limiting paper requested; and (ii) reusing paper (e.g. using paper both sides, and reusing the used paper once again).

<u>23rd Recommendation</u>

For effective paper use and management, all hospitals should apply *'effective monitoring and reporting systems'*. This means authorising a housekeeping worker to report to the Head of Department or Environmental Team when he/she finds non-reused paper in the waste bag. In turn, the Head instructs subordinates to improve paper-saving performance.

Tips:

- ✓ Applying too strong a reporting system or antagonizing staff by undertaking working demotion, caution and blame, can bring resistance and internal conflict. In consequence, the SEP concept, particularly the harmonious community, should be simultaneously employed.
- ✓ All hospital departments should have separate containers to collect single-use paper, for further reuse.

24th Recommendation

All hospitals should reduce paper by using an electronic method of data processing (e-logistics) as opposed to a paper based system. This IT system supports data transmission and sharing, as well as reducing the workload and risk of litigation.

Downside:

- ❖ The downside to this is that it can generate electronic waste that is hazardous and using more electricity.

6.2.7 Effective Microorganisms (EM)

25th Recommendation

Based on the study findings, it is advocated that all public hospitals should implement EM production. The pure EM liquid must be further utilized to produce several products (e.g. dishwashing liquid, detergent and liquid soap). It is in particular producing ‘high-quality sterilisation liquid’, to clean infected linens, medical devices and floors of operating theatres, for example.

This is because Thailand regularly imports chemical sterilisation liquid, which is too expensive for public hospitals with limited budgets; and needs long transportation lead times to many rural hospitals.

Conditions Required:

- ✓ The production process and quality of EM sterilisation liquid should be researched by the government or universities, for example, to ensure the efficiency before being widely implemented.
- ✓ Equipment and knowledge of EM production should be delivered to all hospitals.

Tips:

- Larger hospitals may save millions of Baht and it is with these potential savings in mind that hospitals are encouraged to officially set up an EM plant and have a responsible person to oversee it.
- Sour fruits like lemon, orange and bergamot are the most appropriate EM input, because of their citrus smell and cleaning effectiveness.
- The hospital can follow the guidance from sources such as Electricity Generating Authority of Thailand (2007): *"Biological Way of Life for Sustainable Development: the Road to Sufficiency Economy"*.
- Raw materials like molasses, N70 (surfactant), salt, thickener and flavour are often used for producing EM cleaning liquid, which can easily be purchased at the local market.

6.2.8 Organic Foods

Producing organic foods for both patients and employees ensures reduced pesticides and less environmental impact. When examining this aspect in the course of this study and associated literature, three key practices were noted which hospitals should consider:

<u>26th Recommendation</u>

Hospitals with sufficient free space should have an organic garden for both vegetables and fruits. This is based on an SEP concept, saying: *"Eat everything we grow, and grow everything we eat"*. When employees help cultivate the gardens, it strengthens health and increases internal understanding of the sufficiency and production.

Tips:

- Various fruit trees (e.g. mango, tamarind and rose apple) should be planted, as they have the dual purpose of offering shade and producing edible products.

- To support a closed-loop supply chain, the hospital should use own-produced organic fertilizer (e.g. residues of EM and biogas productions, dried sediment of wastewater treatment plant, and manure). And, vegetable and fruit wastes should be used in the productions of EM, biogas, and fertilizer.

- Rain water or natural water should be collected in receptacles for watering plants.

- The hospitals lacking knowledge and seed/grain can receive support from nearby universities, or the provincial agricultural extension office, or Bank of agriculture and agricultural cooperatives (BAAC).

<u>27th Recommendation</u>

Hospitals with limited space should purchase organic products from local farmers whenever possible. For instance, “C” and “E” regularly cook organic rice for their patients. This indirectly strengthens local economies and self-reliance according to SEP.

Conditions Required:

- ✓ This practice can only be applied when there is an organic farming network near the hospital. As a result, the MOPH should coordinate with the BAAC, which principally supports most organic farming networks in Thailand, to distribute the qualified organic products to all hospitals.

Tips:

- The hospital should receive all food materials available, and adjust the food menu according to it.

- The organic farmers should inform the hospital about their available product types and volumes in advance.

- The hospital should have a rooftop or walled garden, which uses space efficiently and promotes sustainability.

- The hospital may grow a vegetable garden, instead of having a flower garden.

Note: The hospital may apply both organic gardening and purchasing of organic foods to increase the proportion of organic materials in food menus.

<u>28th Recommendation</u>

Hospitals with free space should also grow herbs, and produce herbal products to use in Thai traditional medicine departments and these can be mass produced to sell to others. Some herbs like lemon and bergamot can be used in cleaning toilets to reduce offensive odours (act as a natural cleaner/air freshener).

6.3 Recommendations for Implementation Practices

GL adoption is a human-based system, so its implementation would be seriously compromised without full commitment from the entire organization (Daily and Huang, 2001, Edwards, 2004). Therefore, the most effective implementation practices focus on humans and their actions. This section details key implementation practices for successfully addressing GL practice, consistent with SEP and EMS-ISO 14001 concepts (e.g. NHS, 2001, ESC, 2003, PCD, 2013a). Figure 6-1 presents the recommended cycle that public hospitals should adopt when effectively addressing GL. In keeping with the theme of ongoing continuous improvement, the cycle is continually repeated within an organisation and the model considers education to be the starting point of this cycle. **This general implementation practices can be applied to hospitals of all sizes and in different regions.**

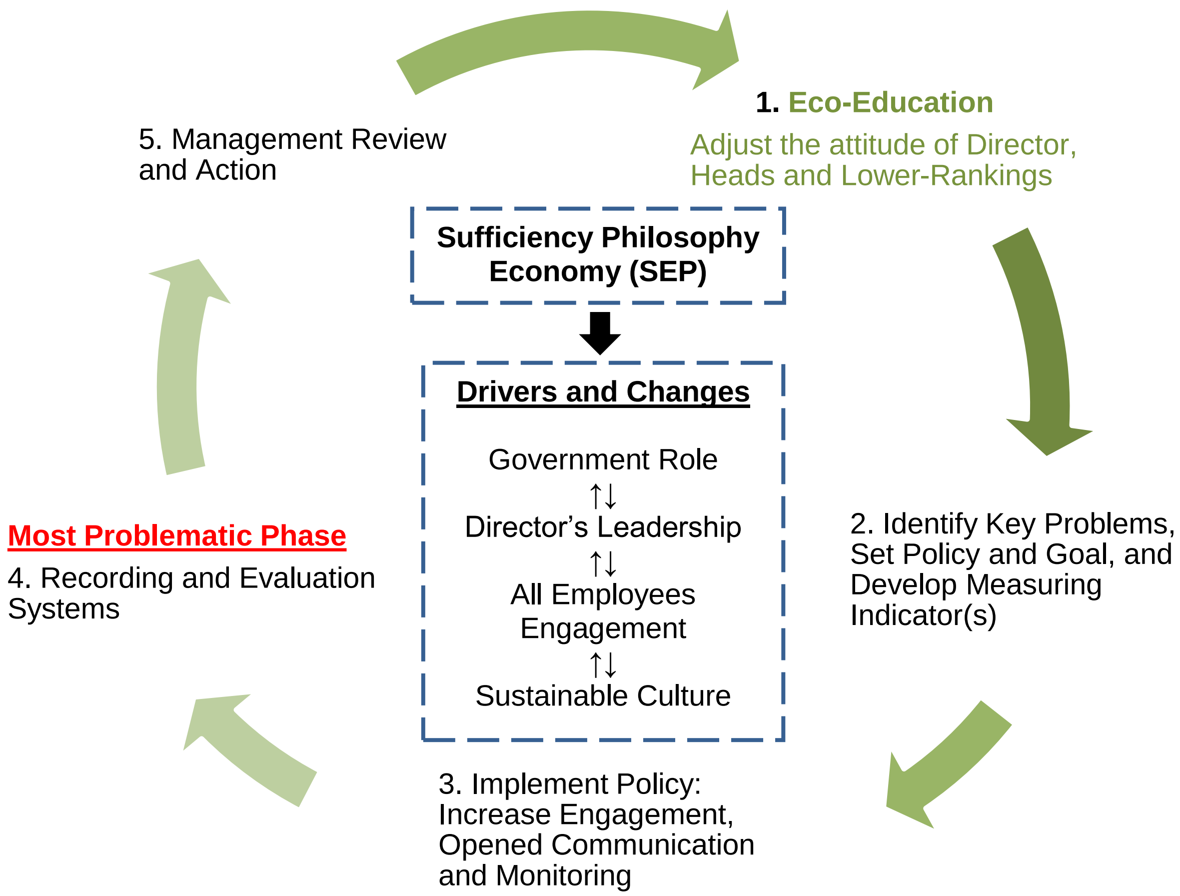


Figure 6-1: The recommended cycle for effectively addressing GL.

Source: Modified from US EPA (2013).

29th Recommendation – Sufficient Environmental Education

All hospital Directors should receive environmental education and develop their understanding of the SEP concept before addressing environmental policy. Increasing understanding by education can influence attitudes towards environmental consciousness as detailed in the cycle, as Figure 6-1.

It needs to start with the Director since this is the key person who decides the organizational direction, and authorises support (e.g. budget and resources). Correspondingly, the Director is a role model of his/her organization, and can deliver excellent knowledge to subordinates, and foster/nurture increased levels of engagement in environmental consciousness.

Tips:

- There are several formats of education to be selected such as study visits, training and self-study.

30th Recommendation – Setting Clear Policies and Goals

All hospitals should set clear ‘Green Logistics’ policies and goals with a limited timeframe for realization of these. Importantly, their developments should be grounded in the SEP concept to ensure the balance of environmental, social and economic elements. Clear goals/policies help determine the future direction, while a limited time frame or deadline provides incentive to take action and move forward (US EPA, 2009, p. 22).

Tips:

- New practitioners should focus on the most important environmental aspect, as dictated/observed by problematic areas, e.g. inefficiency and low performance.

- Mature practitioners are highly recommended to introduce activities which focus on hospital resources/waste and which deliver social and economic impact into the hospital policy.

31st Recommendation – Environmental Team (Env Team)

An Env Team should be established, responsible for developing, promoting-communicating, auditing and reviewing the environmental policy and its performance.

Tips:

- The hospital may create a sub-Env Team to monitor each eco-aspect (e.g. water team, and medicine team) to ensure its effectiveness.
- In its initial phase, the Env Team should comprise all Heads of hospitals, because they can lead and monitor their subordinates. When the Team is firmly embedded and working well, representatives from all rankings should be included in the team to enhance stakeholder opinion and increase engagement.

32nd Recommendation – Open Communication

All public hospitals should create an open communication climate in which the Director is open-minded as well as listening and encouraging staff to express contrary viewpoints (Stark, 2015). Exchanging creative ideas and feedback supports the improvement.

33rd Recommendation – Effective Monitoring

All Directors of case hospitals mentioned low self-discipline as a key problem to effectively manage resources and waste. In light of this, a continual monitoring and feedback system are highly advised.

Tip:

- A more effective result is produced when all staff work together and remind each other to behave in an environmentally-friendly manner at all times.

34th Recommendation – Recording and Evaluation Systems

All hospitals should establish systematic and effective recording and evaluation systems. Key recommendations include:

- Monitor the volumes of resources purchased, requested, and returned,
- Selectively monitor by total, or by practice, or by sub-category of resource/waste,
- Install more meters or technology to collect data on a regular basis,
- Conduct internal audits of stock, waste, and electricity leakage, for example,
- Collect information from all staff grades/levels regarding environmental behaviour,
- Develop a systematic database of carbon reduction, cost, and assorted analysis, for example.

Note: that this measurement stage is the most problematic area as highlighted in Figure 6.1, because most case hospitals:

- Have no indicators or appropriate indicators,
- Have no standard unit of measurement,
- Do not (regularly) record, audit, and review set outcomes, and,
- Have insufficient technology to support the recording system (e.g. meters).

(For instance, on examining the effectiveness of the reducing paper policy, four case hospitals (“A”, “B”, “E” and “F”) have never reviewed paper use (reams) or volume of paper reused.)

35th Recommendation – Management Review and Action

GL practice’s performance should deliver comprehensive data which is analysed on a regular basis and action taken accordingly. This could link to a reward system to support ongoing engagement and encourage additional uptake.

6.4 Recommendations for the Government

Based on the above 35 recommendations and previous findings, this section develops ‘three-critical-step recommendations’ for the government to support and increase the GL adoption in all public hospitals. This is because: (i) many GL practices (e.g. biogas and EM productions) are very beneficial; and (ii) the government is the key driver for adoption through their policies, budget allocation, and support and system development.

<u>1st Step: Include GL practice adoption in Hospital Accreditation (HA)</u>

Currently, nearly all public hospitals are involved with HA (NHSO, 2013). Therefore it is a natural and logical assumption that GL practices are related to and to an extent contained within HA. For example, the improved performance of both environmental and medical operations is a key evaluation criterion of HA. If GL has become a compulsory practice (as demonstrated by the HA), it highly supports national development and the SEP agenda. This occurs via reducing resource use/waste and budget, supporting sustainable health systems and promoting self-reliance.

<u>2nd Step: Provide knowledge and support</u>

Since the Hospital Director’s understanding of SEP and GL concepts correlates directly to the adoption success, consequently a programme designed for ‘Environmental Training for Hospital Directors’ should be provided. The benefits of GL practices (e.g. environmental and financial benefits) should be a strong incentive for such training to be designed and delivered. Later, each Regional Health Office may organize such training for other employees.

(i) <u>Knowledge</u>

Guided by this study’s outputs and current theory, the government can develop a knowledge database/website/manual. This source should contain information and guidance/support relating to the SEP concept, GL practices, implementation practices, logistics and supply chain, recording systems, evaluation system, and critical support contacts. A mentor system to match experienced GL hospitals with new practitioner hospitals should also be established.

(ii) <u>Establish a dedicated GL Research Group (see also section 6.5)</u>

The key role of these researchers is to investigate new and developing GL areas of innovation/practice and opportunities:

- *Medicine and Medical Supply*: effectiveness of reducing medicine, returned medicine programmes, appropriate turnover rate, reusing single-use medical device, and practising meditation and its outcomes,
- *Biogas Production*: improving biogas pressure, and its feedstock supply chain,
- *EM*: developing high-quality EM sterilisation liquid,
- *Organic Farming*: improving organic material supply chain, and,
- *Infectious Waste (IW)*: developing cheap and effective IW incinerator.

[**Note**: All case hospitals decided not to operate IW incineration because of high energy/electricity cost, and difficulty in managing hazardous ash.]

(iii) <u>Finance and Green Technology</u>

The government should focus on these more resource consuming and technical practices:

- Construct a biogas plant,
- Acquire tools for EM production,
- Advocate that all hospitals install more electric meters
- Support installing electricity-saving technologies, and,
- Provide more IW incinerator and HW handlers, based on the fact that now Thailand has only 14 incinerators (PCD, 2013c), and only two HW handlers (Tangpaitoon, 2012, Ministry of Public Health, 2015).

3rd Step: Strengthen many ineffective policies

This research has shown that many government policies/systems/directions have negatively affected GL performance in public hospitals. Examples of this include:

- *The 30-Baht scheme* increases financial crises and has led to a lack of key resources,
- *10% cost reduction of medicine and medical supply* leads to the selection of cheap but poor quality medical resources,
- *HOSxP* and *e-GP* are not well-developed leading to the use of an unstable system and an increase in paper consumption,
- *The HA-paper system and other paper-based systems* increase paper consumption and there is low data integration or data transmission,
- *Several approval processes* increase lead times, which undermine the effectiveness and quick processing of patients for medical operations,
- *The high-developed hierarchical system* generates limited opportunities for or acceptance of problem solving discussions.

In fact, solving or strengthening many ineffective policies/systems is a long-term effort, which can only be done by simultaneously engaging with the first and second steps above. The MOPH should:

- Consider solving problems based on the hospital feedback,
- Develop policy by cooperating with a public hospital network, and
- Ensure the effectiveness of new system/guideline before its deployment into policy.

6.5 Summary of Recommendations and Applicability

Practices presented in sections 6.2-6.4 can be summarized and their applicability demonstrated as Tables 6-1 and 6-2 below.

Table 6-1: GL Physical Practices and Applicability

In general, the hospitals have different settings to introduce new policies, such as hospital location, size, readiness and budget; so that the hospital must choose what suits them and the pace of implementation. These concerns can be found in Table 6-1 under the caution/tip and feature columns.

Table 6-2: GL Implementation Practices and Government Roles

The government can offer excellent support by providing: a clear commitment to GL awareness; an environmental training programme, clear GL adoption guidelines (e.g. practice and indicators), open communication channels/forums, and budget and technology allocation. Moreover, several existing challenging regulations/policies/systems which negatively impact on GL practice success should be reviewed and updated based on current research such as this.

Short Summary

These practices are not only crucial for Thai hospital, but also important for healthcare in other countries, professions (e.g. service improvement and building design) and other stakeholders (e.g. patients and suppliers) that are facing the same problems. To do this, all hospital Directors and staff should receive sufficient training regarding 'Sufficiency Economy Philosophy' (SEP) and fundamental logistics operations (Figure 3-4). This is because SEP supports using resources only as needed and taking care of the environment and social system. Regarding the logistics concept, it is a general framework that can apply to hospitals of all sizes and helps to realize their own logistical flow and related environmental impacts. Consequently, both SEP and the logistics diagram help to better implement GL practices.

Table 6-1: Best GL Physical Practice Recommended and Applicability.

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
1. Medicine	a) Dispense chronic medicine for only 1 month instead of 4-5 months, plus more frequent follow up	❖ **Health promotion** ❖ **Medicine used reduction (a. ≥ 5%)** ❖ **Lower stock shortage** ❖ **Cost reduction (b. ≥ 100,000 Baht/yr)** ❖ **Support local economic (especially for c.)** ❖ **Reduce illness (e.g. mindfulness can reduce blood pressure)**	** Need more time / staff for dispensing medicine and follow up - Policy is well communicated to all staff	All types and sizes of hospital	Develop/adjust the standard of prescribing medicine
	b) Adopt a returned medicine program		** Need more time / staff for checking medicine -Select only key items (by e.g. volume or cost)		Set a clear guideline for returned medicine
	c) Increase use of herbal medicine, and Thai traditional treatment		-Receive herbal products from local community/ produce by hospital itself	Must have this department/ space	-Set a clear goal of herbal medicines use -Need more research and development
	d) Establish a sustainable health system e.g. exercise, practise mindfulness, and adjust eating habits		- Staff are well-educated and on-going giving knowledge to patients	All types and sizes of hospital	- Set a clear guideline - Confirm the benefits of mindfulness - Coordinate with organic farming networks across country

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
2. Medical devices	e) Use more multiple-use devices (glass and metal types), instead of increase single-use devices	❖ **Promote infection control** ❖ **Reduce resource and waste (about 2-3 times)** ❖ **Reduce cost on infectious waste incineration** ❖ **Reduce devices imported**	** At first it may require high budget to purchase multiple-use devices. - Improve sterilisation processes, and quality assessment - Use own produced EM for cleaning devices	All types and sizes of hospital	- Replace policy of increase single-use devices, by increase multiple-use devices - Set the guideline for using and cleaning multiple-use devices (e.g. how many times that devices can be reused?)
3. Electricity	f) Implement hardware-systemware-peopleware concept	❖ **Mainly support sustainable use of electricity** **(can save up to 9 million Baht/yr for 500 Bed size)**	-Establish this policy across the hospital -Provide annual training to update policy and practice knowledge - Create energy-saving team to monitor their responsible areas - Report the progress and future plan regularly	All types and sizes of hospital	- Should be part of HA, and being a mind-set of reducing electricity usage
	g) Set air-conditioning system at 26-27C with the highest fan speed	❖ **Reduce electricity usage and cost (up to 1.3 million Baht/yr for 500 Bed size)**	- Maintain air conditioners regularly, by well-trained staff in all departments	All types and sizes of hospital	-

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
	h) Promote good air ventilation rather than using air conditioner	❖ **Reduce electricity usage** ❖ **Improve infection and disease control**	- Raise the roof - Install water evaporation - Have more trees and gardens ** Need budget for change		- New building/ renovation should adopt 'sustainable Building design' concept
	i) Install saving energy devices, use pull-switch lighting, and set time for using appliances	❖ **Reduce electricity usage and cost** ❖ **(pull-switch can save up to 47,000 Baht/yr)**	** Need budget for installing appliances/ meters depends on need ** Require proficient technician		-Set strong measures of saving energy for all types of hospital
	j) Each key building/ should have own electricity meter				- Allow separating meter in hospital
	k) Define a unit of analysis, and regularly review	❖ **Better measurement of electricity usage**	** Require knowledge and/or software to collect the data		- Provide the standard of analysis unit and software

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
4. Biogas	I.1) *Biogas plant* using e.g. food waste or manure 	❖ **Reduce energy use (e.g. diesel and LPG) (save LPG 25%-50%)** ❖ **Reduce all hospital food waste** ❖ **Get EM liquid and solid fertilizer** ❖ **(No need to buy fertilizer)**	* Biogas plant costs around 0.5-1 million Baht (depends on kilowatt)[7] * Require proficient technician for maintenance - Supported by the Ministry of Energy, and some universities	-Large-sized hospital, having a large amount of e.g. food waste	- Improve gas pressure - Provide support of budget, knowledge, equipment, and maintenance -Provide incentive of increasing biogas
	I.2) *Blanket biogas* plant using e.g. food waste or manure 		- Biogas generator with plastic bag/blanket, the cost can be lower than 400,000 Baht[8]	-Small-sized hospital with a small amount of waste	

[7] https://thai.alibaba.com/f/%E0%B8%A3%E0%B8%B2%E0%B8%84%E0%B8%B2-biogas-generator.html

[8] http://thaibiogasgen.blogspot.com/2015/08/2.html

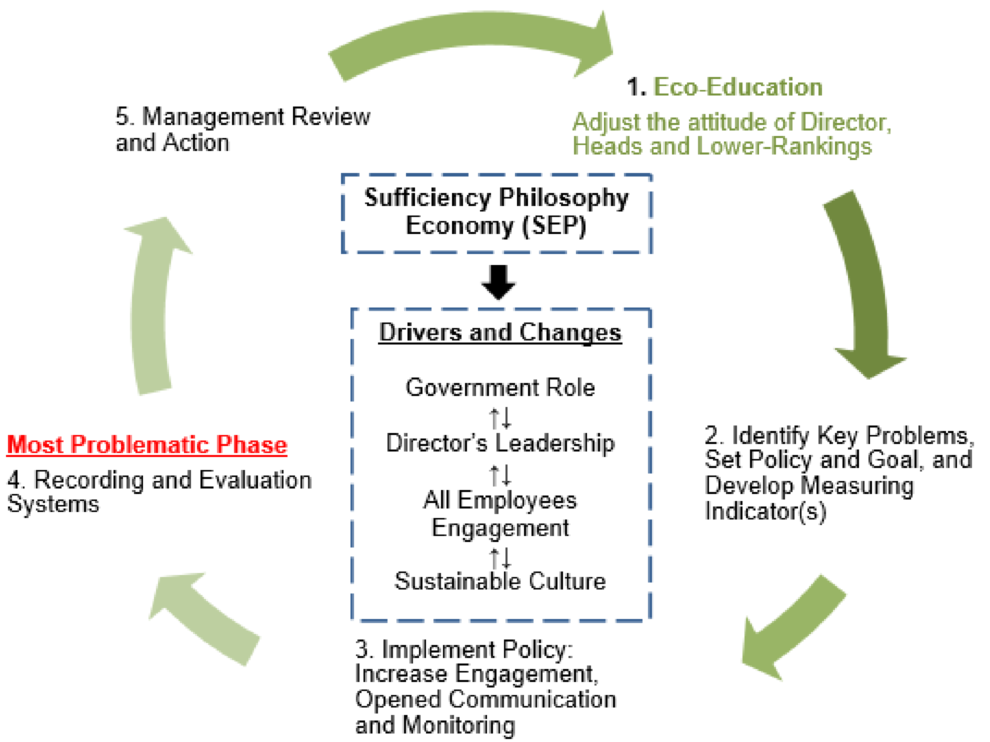
Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
5. Infectious waste and sharps	m) Embed regular monitoring system on waste sorted and waste collection	❖ **Improve infection control** ❖ **Reduce IW volumes and incineration cost**	-Sufficient and on-going education -Have enough waste bin for all types of waste -Provide pictures telling how to sort waste (for illiterate) -Randomly check waste bag to ensure the waste segregation -Tag waste bag at source	All types and sizes of hospital	- HA should randomly/ continually observe this practice - The MOPH should regularly review the volume of IW by the hospital and in total
	n) Educate patients and relatives on how to sort waste correctly				
6. Recyclable waste	o) Sort and sell waste by a housekeeper or department	❖ **Reduce waste volume (≥ 7,000 – 30,000 kg)** ❖ **Increase revenues (≥ 20,000 – 130,000 Baht)**	-Sort waste in to four types: cardboard, paper, plastic bottle and glass bottle	Hospital having a small volume of waste	
	p) Establish a hospital recycling bank, to collect this waste and sell by the hospital.		- Sort waste according to selling prices - Have a clear recording and revenue allocation systems	Hospital having a large volume of waste	-Set a clear revenue allocation system - Include a recycling bank in HA

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
7. Saving paper	q) Embed effective monitoring and reporting system on paper request and paper waste	❖ **Reduce paper use (up to 500 reams, for 150 bed size)** ❖ **Reduce paper waste** ❖ **Reduce cost** ❖ **E-logistics increases data integration and exchange, and reduces storage space for paper documents.**	- Authorize housekeeper to report Head if found non-reused paper in the waste bag - Collect single-use paper to be reused later	All types and sizes of hospital	- The government communication method should reduce paper usage.
	r) Increase use of information system (e-logistics)		** Increase use of electricity, budget on computer supply, and IT hazardous waste		
8. Produce Effective Microorganisms (EM)	s) Produce EM from local resource, and use it to produce cleaning liquid for kitchen stuffs, floor, hands, and linens	❖ **Use waste/ resource effectively** ❖ **(Use all food waste)** ❖ **Reduce use of chemical** ❖ **(s. – no chemical**	-Can use waste from vegetables, fruits, raw meat and cooked foods - Production materials can be found locally -Ensure the quality of EM liquid and sterilisation liquid	All types and sizes of hospital	-Research and develop the effective EM formula for various products -Provide equipment and knowledge

Item	Practice	Benefit	**Caution/ -Tip	Feature	Government
	t) Use EM liquid to produce high-quality sterilisation liquid	**products used)** ❖ **Reduce imported products** ❖ **Increase cost saving** ❖ **(s. and t. save ≥ 0.4 -1 million Baht)**	-Very low cost of investment (Cost is mostly from purchasing barrels for fermentation.)		
9. Organic Foods	u) Use/Produce organic foods for patients from fresh organic vegetables, fruits and meat	❖ **Support health promotion** ❖ **Use local product and support local economic (SEP)** ❖ **Use less market product and reduce cost (save up to 25%)**	-Grow own organic products -Purchase organic products locally -Use foods waste to produce EM or fertilizer -Use rain water for watering plant	Only hospitals with sufficient space and/or located near organic farming network	-The MOPH should coordinate with organic farming network to supply their products to hospital

Table 6-2: Best GL Implementation Practice and Government Roles.

The recommended cycle for effective addressing GL



Step of Implementation	Details
Step 1: Provide sufficient education, starting from the Director e.g. SEP and logistics	-Benefits from the adoption are informed.
Step 2: Set a clear goal and policy *New practitioner*: focus on key aspects *Mature practitioner*: try achieving SEP	- SEP helps to reach a sustainable goal.
Step 3: Establish Environmental Team, which members are from all departments	-The team can monitor its area.
Step 4: Establish open and two-way communication	-Exchange idea and give feedback
Step 5: - Have effective monitoring, recording and evaluation systems -Ongoing review and take action	** These systems should be developed by the government

Government Support
- Include GL practice in Hospital Accreditation System (HA) - Provide sufficient knowledge and support (guideline, budget, assistance, and equipment/tool) - Establish a dedicated GL research group - Strengthen many ineffective policies (e.g. paper-based communication and 10% cost reduction of medicine)

6.6 Limitations of Study and Future Research Opportunities

(i) <u>Future Predictions</u>

Green logistics (GL) and the range of practices that deliver this are very important to healthcare operations because of issues such as national direction/strategy and sustainable trends. What is more, patients who expect faster and better quality of medical services, as well as a better hospital environment, are a major driver in healthcare improvement and development. For that reason, the hospitals have to be open to improvements in their operations. In addition, the concept of the green supply chain should be embraced.

If hospitals choose to ignore GL practices, their poor environmental and logistics performance could cost them dearly (e.g. greater cost of handling eco-impacts, work redundancy/error/slow/inefficiency, and poor medical services). Poor hospital performance can also belatedly generate problems such as weak patient safety, poor social-relations and a damaged hospital reputation.

(ii) <u>Limitations of Research</u>

Whilst this study was comprehensive in its analysis in delivering to the research objectives, as with all studies it had its limitations. These are highlighted below.

- The hospital GL system comprises of practice in 3 key areas: environmental, healthcare, and logistics. Many hospital staff contributed to this research to give an accurate representation of GL practice in each operation. The staff input was evident in all stages of this study, from THP preliminary study, pilot study, research design and analyses through to recommendations. The researcher acknowledges that she has limited healthcare knowledge and that this can impact the research validity and reliability. Nevertheless she attempted to counteract this issue by her close alliance with and communication with key healthcare personnel throughout the study.

- A small respondent sample (6 case hospitals) can result in low generalizability. The researcher attempted to negate this by her extensive interview database with staffs of case hospitals, by using one-to-one interviews with all grades of hospital staff.

- There was limited access to some hospital documents, which can affect the accuracy of identifying best practices.

- This study shows that environmental education can raise awareness and adjust behaviour. Still, their causal relationships cannot be drawn, since it is outside the scope/purpose of this research project.

(iii) Develop GL Research Network

Thailand currently has an insufficient body of knowledge, supported infrastructure (e.g. hazardous waste and infectious waste handlers and government commitment), and GL researchers who can work to improve hospital GL adoption. These issues should be addressed by developing a research network which comprises environmentalists, logisticians, healthcare professions, and financial or cost analysts all of which should be supported by governmental bodies (see Figure 6-2).

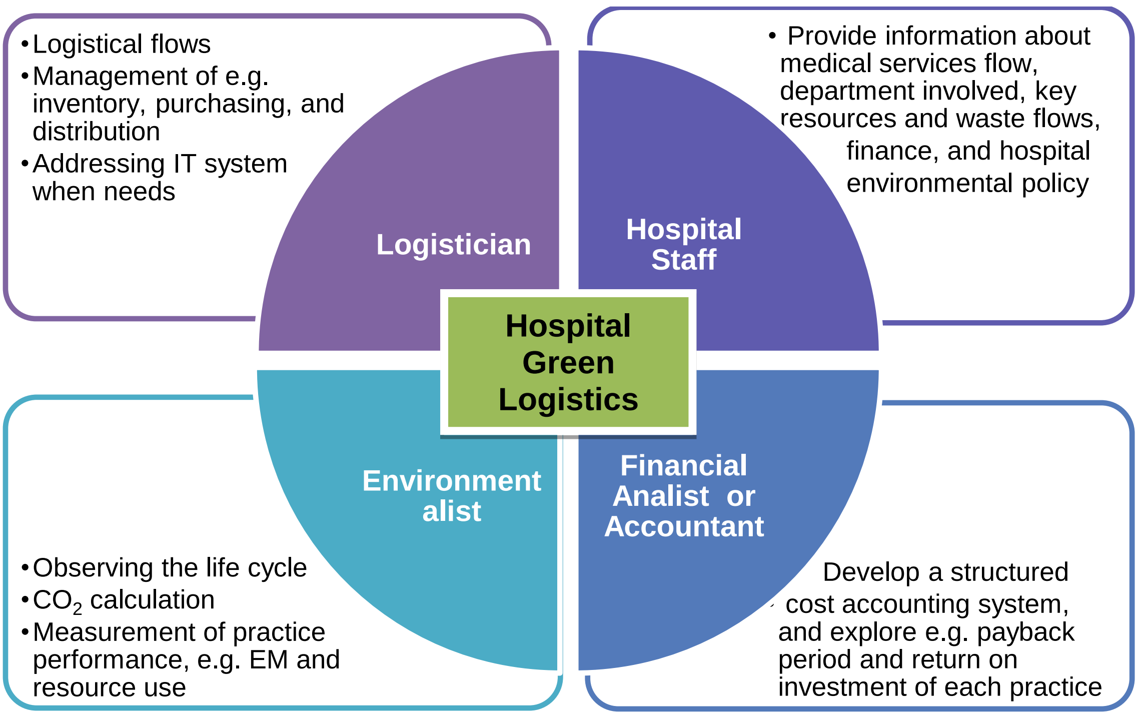


Figure 6-2: Potential research roles in future GL research.

For example, a hospital staff member can give clear information of patient flows from registration to admission, which a logistician can then use to map out patient flows. At the same time, an environmentalist can assess key resources allocated/used and waste generated from these processes, and an accountant working in tandem with these parties can present budget spent or savings on the above flows.

(iv) <u>Future Research Opportunities</u>

In this section future research opportunities are outlined. These are by no means exhaustive but offer an insight into the future direction of GL exploration in the Thai healthcare system and other avenues.

- Replicate this study's design to explore GL adoption in the private hospital sector, or the other 13 key Thai industries (as identified by the 2nd National Logistics and Supply Chain Research Strategies), and in other developing nations,

- Replicate the outputs generated from this study with an increased number of case hospitals to ensure validity and generalizability,

- Use a hospital logistics diagram (Figure 3-4) and healthcare supply chain diagram (Figure 3-3) to further investigate logistical flows, e.g., inpatient flow, radioactive waste flow, and blood cold chain,

- Explore the concepts of how to raise environmental awareness, and how the awareness can adjust behaviour, attitudes, and overall organizational performance,

- Undertake comparative studies, e.g. UK, in the following areas: (i) application of SEP; and (ii) adoption of EM, and,

- Investigate a sustainable way of living knowledge, including its practice and outcomes.

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Appendix 1: Definitions of Green Logistics

Author	Green Logistics Definition
1. Rogers and Tibben-Lembke (1998, pp. 102-103)	Green logistics, or ecological logistics, refers to understanding and minimizing the ecological impact of logistics. Green logistics activities include measuring the environmental impact of particular modes of transport, ISO 14000 certification, reducing energy usage of logistics activities, and reducing usage of materials. Some GL activities can be classified as reverse logistics such as reusing and remanufacturing.
2. Beamon (1999)	Green logistics can be regarded as part of green supply chain management (GSCM) that aims at integrating environmental thinking into closed-loop supply chain management). GL is an approach that considers the environmental impacts of procurement, transport, inventory control, and distribution activities along with other considerations in order to minimize environmental costs. In order to achieve GL, organization must follow the basic principles established by ISO 14000. In particular, organization must develop procedures that focus on operations analysis, continuous improvement, measurement and objectives.
3. Rodrigue et al. (2001a, p.1)	Green logistics is environmentally-friendly and efficient transport and distribution system.
4. Carter and Jennings (2002)	Logistics Social Responsibility (LSR) is defined as the activities of the purchasing, transportation, and warehousing managers fell into five to six broad categories that include the environment; ethics; diversity; working conditions and human rights; safety; and philanthropy and community involvement.
5. Rogers et al. (2002)	Green logistics is the attempts to measure and minimize the ecological impact of logistics activities. They include green purchasing, green material management and manufacturing, green distribution and marketing, as well as reverse logistics
6. Sathaye et al. (2006, p.4)	Green Logistics can be thought of as an approach for planning freight logistics systems that incorporates sustainability goals with a primary focus on the reduction of environmental externalities
7. Sbihi and	Green Logistics is concerned with producing and distributing

Author	Green Logistics Definition
Eglese (2007)	goods in a sustainable way, taking account of environmental and social factors. Green Logistics activities include measuring the environmental impact of different distribution strategies, reducing the energy usage in logistics activities, reducing waste and managing its treatment.
8. Carter and Rogers (2008)	(green logistics is not "new" in terms of re-inventing logistics, but) it stresses the integration of ecological goals into the target systems of organizations and value chains in order to provide a balanced set of total value to customers.
9. Ping (2009, pp. 339-340)	Green logistics refers to when damage to environment is restrained in the course of logistics, the purification of logistics environment and making logistics resources to its full use. The purpose of green logistics is to realize economic benefits of certain subject, and at the same time, to look after saving resources, protecting environment especially.The Green Logistics Management stressed the overall situation and long-term interests, emphasized all-round concern for the environment, reflected the green image of the corporation, which is a new trend in logistics management. Green logistics is adapted to the requirements of sustainable development.
10. Lin and Ho (2011, p. 74)	Green logistics management focuses on filtering emission, reducing energy and natural resources consumption, reducing waste, and optimizing materials exploitation.
11. Thiell et al. (2011, p.335)	i) Green logistics is systems that employ advanced technology and equipment to minimize environmental damage during operations, while increasing the utilization of resources within the systems. ii) Green logistics consist of all activities related to the eco-efficient management of the forward and reverse flows of products and the point of consumption whose purpose is to meet or exceed customer demand.
12. Choi (2012)	Green logistics management refers to detailed eco-friendly logistics practices on diverse types of logistics process.
13. Lai et al. (2012, p.766)	Green logistics management (GLM) aims to deploy processes that produce and distribute goods in a sustainable way, with a view to reducing waste and conserving resources in performing

Author	Green Logistics Definition
	logistics activities. GLM can be viewed as a management approach by which firms formally manage, evaluate, report, and control the environmental impacts of their actions throughout the life cycles of their products. This management approach requires firms to: (i) adopt procedures to formally operate, document, and report their logistics activities, (ii) conduct evaluation of their performance, (iii) inform and communicate with various stakeholders regarding their logistics activities, and (iv) comply with environmental standards.
14. Rodrigue et al. (2013)	Green Logistics is supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It focuses on material handling, waste management, packaging and transport
15. Logistics Cluster (2013)	Green logistics is to coordinate the activities within a supply chain in such a way that beneficiary needs are met at "least cost" to the environment. It is a principle component of reverse logistics. … "Cost" can now also be understood as the external costs of logistics associated with: climate change, air pollution, dumping waste (including packaging waste), soil degradation, noise, vibration and accidents,

Appendix 2: Key Themes and Patterns of Green Logistics Study

Author	Key Study Issus	Method	Region	Industry	Outcome
1. Poist (1986)	Evolution of conceptual approaches to designing business logistics systems	Literature Review	N/A	N/A	Information and Research Gaps
2. Szymankiewicz (1993)	Going green: the logistics Dilemma; pressures, responses, key environmental issues, practical GL practices, future perceptions	Survey Questionnaire (Head/manager of organization)	UK	Members of CLM (or currently called CSCMP)	Best Practices, Information
3. Murphy et al. (1995, 1996)	GL drivers, barriers, key environmental issues, strategies, policies, practices, logistics' role, corporate' views, future perceptions, top management support, firm sizes, firm types	Survey Questionnaire (Head/manager of organization)	US	Manufacturing and merchandising	Best Practices, Information
4. Wu and Dunn (1995)	More environmentally responsible decisions of managers: economic vs environment, best practices, environmental issues, green vs logistics concepts, and constraints	Literature Review	N/A	N/A	Best Practices, Models, and Research Gaps
5. McIntyre et al.(1998)	GL measurements	Literature Review	N/A	N/A	Information, and Research Gaps
6. Skjoett-Larsen (2000)	EU logistics trends beyond 2000, GL key areas	Literature Review	EU	N/A	Information, and Research Gaps
7. Murphy and Poist (2000, 2003)	GL strategies, environmental issues, practices, drivers, GL activities, future directions	Survey Questionnaire (Head/manager of organization)	US, Canada, EU	Manufacturing and merchandising	Best Practices, Information
8. Rodrigue et al. (2001a)	GL and environment paradoxes it creates in logistics	Literature Review	N/A	N/A	Information, and Research Gaps
9. Carter and	CSR concepts like environment,	Interview	US	Members of	Information

Author	Key Study Issus	Method	Region	Industry	Outcome
Jennings (2002)	safety, and ethics in logistics activities, drivers, barriers, ways of overcoming barriers, and outcomes	(Manager of organization)		CLM (or currently called CSCMP)	
10. Geroliminis and Daganzo (2005)	GL schemes used in cities around the world, and the application to other cities	Literature review	N/A	N/A	Information, and Research Gaps
11. Aronsson and Brodin (2006)	The changing logistics structures impact on costs, delivery services and environmental impacts.	Literature Review and Case Studies (of 3 companies/distributors)	Sweden and EU	Grocery, furniture, and paper	Best Practices, Model, Information and Research Gaps
12. Gonzalez-Benito and Gonzalez-Benito (2006)	Stakeholders' pressures on GL implementation as perceived by firms' managers	Survey Questionnaire (production and operations manager)	Spain	Chemical, electronic, furniture, and fixtures	Information and Model
13. McKinnon (2006)	A history of GL research in UK	Literature Review	UK	N/A	Information and Research Gaps
14. Sathaye et al. (2006)	Externalities, drivers, barriers, the results of GL on economic and social, solutions to reduce externalities	Literature Review, Interdisciplinary Analysis	Mostly US	N/A	Information, Research Gaps, and Best Practices
15. McKinnon (2007)	UK data of CO_2 emissions from freight transport	Literature Review	UK	Freight transport	Information and Research Gaps
16. Sbihi and Eglese (2007)	The design solution in GL by using combinatorial optimization	Literature Review, mathematic methods	N/A	N/A	Best Practices and Models
17. Frota Neto et al.(2008)	Efficient GL network and the results of impacts minimization	Case studies and multi-objective programing	EU	Pulp and paper	Best Practices, and Model
18.Sugata (2008)	GL benefits, GL best practices, drivers, how to meet CSR logistics	Literature Review	Japan	N/A	Research Gaps, Best Practices and Models
19. Yoshifuji et al. (2008)	Information modelling to calculate CO2 emissions caused by distribution and its allocations for decision making	Mathematic model and analysis	Japan	N/A	Information, model

Author	Key Study Issus	Method	Region	Industry	Outcome
20. Engelseth et al. (2008)	Seafood export from Norway, environmental concern, selecting rail mode of transport	Literature Review	Norway	Seafood export	Information and Research Gaps
21. Suzuki et al. (2008)	Efficient GL in home delivery business	Survey-Questionnaire (e.g. student, full-timer, housewife)	Japan	Home delivery	Information
22. Chaisurayakarn et al. (2008)	GL and RL in Thai battery sector: Nokia and Ericsson	Case study and semi-structured interview	Thailand	Telecommunication	Model and information
23. Piecyk and McKinnon (2009)	Identify the key factors affecting UK road transport demand, amount of fuels consumption and CO2 emissions in 2020	Focus group of specialists and Delphi survey	UK	N/A	Information
24. Cherrett et al. (2009)	The strategies for promoting GL in urban logistics of both profit and non-profit shops	Case Study and surveys to retailers (store managers)	UK	Charity shop	Best Practices
25. Ho et al. (2009)	Drivers of GL implementation of innovations	Questionnaire-Logistics firms	Taiwan	Logistics	Information
26. Ping (2009)	the problems of Chinese GL, the effects of logistics on environment, relationship between GL and SD, and, GL strategies	Literature Review	China	N/A	Information, Research Gaps, and Best practices
27. Lieb and Lieb (2010)	GL goals, initiatives and its impacts on the firms, and impacts of global recession (2008-09)	Survey Questionnaire (CEO of organization)	North America, EU, Asia	3rd Party logistics provider	Information and Best Practices
28. McKinnon (2010)	The history of green logistics, and GL rhetoric and reality	Literature Review	N/A	N/A	Models
29. McKinnon and Kreie (2010)	the key areas of GL to be researched (the gaps)	Literature review, brainstorming and discuss with specialists	N/A	N/A	Models, Graphs and Information

Author	Key Study Issus	Method	Region	Industry	Outcome
30. Choi and Zhang (2011)	Causal relationship between (i) proactive GL and SD performance, and (ii) synthesize green awareness and strategies influence GL policy	Internet questionnaire, and test hypothesis (staff, section chief and manager)	China	logistics	Model and Information
31. Dey et al.(2011)	The reasons for adopting GL and implementing practices	Literature Review	N/A	N/A	Best Practices, Model, Information and Research Gaps
32. Lau (2011)	The development and use of a green logistics performance index (GLPI) for easy comparison of performance	Survey Questionnaire (logistics manager) and analysed by ANOVA, PCA	China and Japan	Home electronic appliance	GL Measurement, Information
33. Lin (2011)	The previous GL studies	Literature review	N/A	N/A	Information and Research Gaps
34. Lin and Ho (2011)	Factors of GL Adoption	Survey Questionnaire (logistics managers)	China	Logistics	Information
35. Montreuil (2011)	The study of current GL practices' performance, and unsustainable symptoms; from physical internet view	Literature review, Case studies and simulation analysis	N/A	N/A	Best Practices, Information and Research Gaps
36. Xuezhong et al. (2011)	The development of GL system architecture; GL strategies and measurements	Literature review, model development	China	Electrical appliances retail trade	Research Gaps, Models and Best Practices
37. Thiell et al. (2011)	GL practices and the implementation in emerging markets	Literature review, Case study (BP Oil)	Mexico	Oil	Best Practices, Model, and Information
38. Ubeda et al. (2011)	Logistics manager role in leading the initiative in the daily decisions, GL practices particularly in transportation	Case study & Interview, and application algorithms (all levels in organization)	Spain	Food distributor	Best practices, and Information
39. Tacken et al. (2011)	Environmental measurements and standards applied by logistics	Multiple Case Studies and Interview (logistics	Germany	Logistics	Best Practices and Indicators

Author	Key Study Issus	Method	Region	Industry	Outcome
	providers	managers)			
40. Choi (2012)	Causal relationship between (i) proactive GL and SD performance, (ii) synthesize green awareness and green strategies influence GL management, (iii) develop the relationship model	Interview (face-to-face, and telephone), fax & email questionnaire, and test hypothesis (staff, section chief and manager)	Korea	Logistics	Model and Information
41. Dekker et al. (2012)	GL aspects, issues, contributions and challenges	Literature Review	N/A	N/A	Best Practices, Information and Research Gaps
42. Lai et al. (2012)	Pressures of GL implementation of export manufacturers	Survey Questionnaire (manager)	China	Export manufacturer	Information
43. Pishvaee et al. (2012)	The development of mathematical programing model for designing GL strategies to cope with uncertainty conditions	Literature Review, Develop model	N/A	N/A	Research Gaps, Model
44. Zhang and Zhao (2012)	Green Packaging, drivers, and best practices	Literature Review	China	Logistics	Information, Research Gaps, and Best practices
45. Martinsen and Björklund (2012)	Gaps in GL market between logistics service providers and shippers' green demand	Web-based survey	Sweden	Logistics service provider and shipper	Model, and information
46. Chaisurayakarn et al. (2013)	The Interaction between green service quality and logistics service quality competencies	Literature Review	Thailand	Logistics	Research Gaps, Indicators of green service quality
47. Göçer and Tuna (2013)	Sustainable programs of logistics companies	Interviews (managers)	Turkey	Logistics (air, road, sea, rail)	Information
48. Pahlén and Carlson (2013)	Analysing the impact of sustainability on freight transport	Case Study (Interview Open-ended type)	N/A	Freight transport	Information

Appendix 3: List of Country Classification (UN, 2012b)

Table E
Economies by per capita GNI in 2011[a]

High-income	*Upper middle income*	*Lower middle income*	*Low-income*
Australia	Albania	Angola	Bangladesh
Austria	Algeria	Armenia	Benin
Bahrain	Argentina	Bolivia (Plurinational State of)	Burkina Faso
Barbados	Azerbaijan	Cameroon	Burundi
Belgium	Belarus	Cape Verde	Central African Republic
Brunei Darussalam	Bosnia and Herzegovina	Congo	Chad
Canada	Botswana	Côte d'Ivoire	Comoros
Croatia	Brazil	Djibouti	Democratic Republic of the Congo
Cyprus	Bulgaria	Egypt	Eritrea
Czech Republic	Chile	El Salvador	Ethiopia
Denmark	China[c]	Georgia	Gambia
Equatorial Guinea	Colombia	Ghana[c]	Guinea
Estonia	Costa Rica	Guatemala	Guinea-Bissau
Finland	Cuba	Guyana	Haiti
France	Dominican Republic	Honduras	Kenya
Germany	Ecuador[c]	India	Kyrgyzstan
Greece	Gabon	Indonesia	Liberia
Hong Kong SAR[b]	Iran (Islamic Republic of)	Iraq	Madagascar
Hungary	Jamaica	Lesotho	Malawi
Iceland	Jordan[c]	Mauritania[c]	Mali
Ireland	Kazakhstan	Morocco	Mozambique
Israel	Latvia[d]	Nicaragua	Myanmar
Italy	Lebanon	Nigeria	Nepal
Japan	Libya[e]	Pakistan	Niger
Kuwait	Lithuania	Paraguay	Rwanda
Montenegro	Malaysia	Philippines	Sierra Leone
Luxembourg	Mauritius	Republic of Moldova	Somalia
Malta	Mexico	Sao Tome and Prinicipe	Tajikistan
Netherlands	Papua New Guinea	Senegal	Togo
New Zealand	Namibia	Sri Lanka	Uganda
Norway	Panama	Sudan	United Republic of Tanzania
Oman	Peru	Syrian Arab Repuplic	Zimbabwe
Poland	Romania	Turkmenistan	
Portugal	Russian Federation	Ukraine	
Qatar	Serbia	Uzbekistan	
Republic of Korea	South Africa	Viet Nam	
Saudi Arabia	Thailand[c]	Yemen	
Singapore	The former Yugoslav Republic of Macedonia	Zambia[c]	
Slovakia	Tunisia[c]		
Slovenia	Turkey		
Spain	Uruguay		
Sweden	Venezuela (Bolivarian Republic of)		
Switzerland			
Taiwan Province of China			
Trinidad and Tobago			
United Arab Emirates			
United Kingdom			
United States			

Appendix 4: Infectious Waste Handling Guidelines

1. Segregation and Collection

a) IW must be segregated at source.
b) IW waste containers must use red colour and be labelled with “Infectious Waste” and “Biohazard” symbol.
c) All types of IW excluding sharps shall be packed in the red bag which do not exceed 2/3 of the total volume.
d) Sharps shall be packed in the boxes which do not exceed ¾ of the total volume.
e) The waste container must be made from strong material; it should be leak proof and have a lid. Also, it should be easy to clean.
f) Waste must be collected every day according to the schedule.
g) Hospitals should have a certain waste transporting route.
h) Waste bags should not be thrown or dragged.
i) If it is necessary to store IW in the temperature control area, this must be at 10C or less.
j) Waste storage rooms and carts should receive regular cleaning.
k) Trained workers for on-site collection shall be required.
l) The workers need to wear masks, hats, aprons, thick rubber gloves and boots.

2. Transportation

a) Have a special vehicle for transportation of infectious waste
b) The vehicle body is fully closed.
c) Transport infectious waste to the disposal area regularly according to the schedule
d) Trained drivers and workers for transport are required.
e) Specifications/qualifications for the collection vehicle:
    - Minimum controlled temperature of 10C or less
    - Required placard of “Use for IW Transport Only” and the “Biohazard” symbol
    - Required emergency response and communication equipment
    - The vehicle should be cleaned by using disinfectant.

- Qualified personnel in B.Sc. and B.E. for the transportation system control shall be required.

3. Treatment and Disposal

a) In case of management by the incineration company, hospitals should monitor operations regularly.
b) If hospitals operate their own incineration, the incinerator should be checked with regards to its emissions, ashes, and quality of burning.
c) Monitoring and operating reports shall be submitted to the local government every month.
d) IW shall be disposed within 30 days after collecting and transporting from the sources.
e) By using the IW incineration, the incinerator shall have 2 chambers and have to be controlled as follows:
   - Temperature of the 1^{st} chamber of not less than 760C
   - Temperature of the 2^{nd} chamber of not less than 1000C.
f) Emissions shall meet the MOPH standard.
g) The ash from incineration should be securely landfilled.
h) Qualified persons in B.Sc. and B.E. for treatment and disposal system control are required.
i) Trained workers for treatment and disposal operations are required.

Appendix 5: Green Logistics Checklist

Green Logistics Performance	***Environmental Performance***	Complete EMS Process	Goal	To meet sustainable development
			Policy Development	- Focus on main eco-aspects and life cycle of resource - Follow legislations and other requirements - Policy is clear and often updated - Personnel involvement in developing policies - A variety of effective policies
			Establish Policy	- Clear roles and responsibilities - Effective education/training - Effective communication delivered - Director's support: budget, time, resources, and encouragement - Systematic documentation
			Audit and Review	- Have strong indicators and unit of measurement - Frequent evaluation and taking action
		<u>Indicator of Human</u>	- Director is a leader for change, and a role model - Personnel has good eco-knowledge, eco awareness, behavior, and attitude towards sustainable development	

			- Full commitment (or Low internal conflict and resistance) - Corporate cultural change and continuous improvement	
		Indicator of Physical	- Reducing amounts of resource used and waste generated - Increasing amounts of green products	
		1.Purchasing Main Hospital Purchasers - Office/Housework Supply - Office Equipment - Pharmaceutical - Medical Supply and Equipment - Linens - Food Material - Utilities		- Follow government regulations - Select products that are 1. reusable/recyclable 2. organic/ less toxic 3. locally produced 4. energy saving/water saving - Reduce using foam and plastic containers
		2.Stocking and Distribution		- High Turnover rate (< 3 months) - Adopt FIFO system - Low shortage and outdated items - Provide a regular random- check
	Logistics Performance	3.Using Resource		- Use resource economically
		3.1 Single-	- General Waste	- Personnel follow hospital’s waste handling guideline

		Use Waste Handling	- Infectious Waste - Hazardous Waste - Food waste - Waste water	- Waste is sorted and handled properly - Provide ongoing monitoring of both hospital personnel and third parties
		3.2Reusable Waste Handling	Medical and office equipment	- Regular maintenance and/or calibration - Quickly repair - Discard old equipment according to the regulation
			Linens and medical devices	- Clean properly - Conduct quality control frequently
			Reusable/Recyclable Waste	- Reuse waste - Establish a recycling bank/or sell recyclable waste
		Indicator of Overall Logistics	- Small lead time - Good flows of information, inventory and finance - Use e-logistics (information technology)	
Hospital Departments Involved: Purchasing, Office Supply/ Administration, Pharmacy, Catering (Nutrition), Laundry, Laboratory, Wards, Central Sterilisation Unit, Housekeeping, Maintenance and Gardening				

Appendix 6: 12 Questionnaire Forms

The research developed 12 forms of questionnaire. The first one is for hospital directors, which asks their policies and controls of environment, inventory, and waste. Next is the form for all staffs in lower levels than director about their perspective towards hospital eco-management. The last 10 forms ask about inventory and waste controls based on particular function of each hospital's department. The key participants in these functions include:

(i) staffs in purchasing department,
(ii) staffs in inventory office (or called office supply),
(iii) pharmacists
(iv) workers in hospital kitchen and canteen
(v) physicians and nurses in wards
(vi) laboratory technologists
(vii) administrative officers
(viii) workers in laundry services
(ix) workers in central distribution unit
(x) housekeeping workers

I) Questionnaire form for hospital directors

1) How long have you been working in this hospital?
2) Please briefly explain your responsibilities.
3) Do you have an environmental policy?
4) How was it developed?
5) How was it been communicated and implemented?
6) What are the key performance indicators?
7) How effective is the policy?
8) Who is responsible for the policy's implementation? (Is this person, or environmental management team, or senior manager?)
9) How often does the team review/monitor the performance?
10) What were the drivers?
11) What were the barriers? And how to overcome these barriers?
12) What is the policy about reducing inventory used?

13) What is the policy about reducing waste generated?
14) Please assess your hospital's eco-management over the next 5-10 years.

II) Questionnaire form for all staffs in lower levels than director about perspective towards hospital's eco-management

1) How long have you been working in this hospital?
2) Based on your understanding, can you briefly explain your hospital's green policy and practices that you know well or with which you have been involved?
3) Do you know the major reasons that your hospital has addressed the green program? What are they?
4) Which kinds of communication channel have made you aware of the hospital's eco-policy, measurement, and practices?
5) Please give the score for the overall eco-performance of your hospital (where 1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent), and give the reason.

III) Questionnaire form for staffs in purchasing department

1) Can you explain briefly your department's daily operations about (a) approving the request for purchasing, and (b) the process to contact suppliers and place an order?
2) What do you think about the following concepts?
    (a) Selecting products that are recyclable and/or reusable
    (b) Selecting products that are less toxic or toxic-free and organic
    (c) Selecting products from local shops and/or locally-produced
    (d) Selecting products with less packaging.
3) In the past five years, what has been the trend in the level of resource use in your hospital? [an increase, no change, or a decrease - please estimate the percentage of change] And, what is the major reason of that trend?

4) Since your hospital has several practices such as reusing paper and making fertilizer from waste, can these measures reduce particular resource use? And in what significant level (please estimate the percentage of change)?
5) What are the main drivers to minimizing resource use in hospital?
6) What are the major barriers to minimizing resource use in hospital? And how can these barriers be overcome?

IV) Questionnaire form for staffs in an inventory office

1) What are the main categories of inventory that your department is controlling?
2) Please comment briefly about the issues below.
    (a) The re-order point
    (b) Inventory turnover (how many months?)
    (c) The selections of products and suppliers
    (d) Purchasing and receiving new products
    (e) Distributing products to other departments in hospital
    (f) Receiving back the left-over inventory from those departments.
3) Over the last 4-5 years, have you faced these problems: (a) shortage of inventory; (b) old/outdated stock; (c) damaged stock; and (d) long lead times?
4) From the above questions, please give details of (a) the causes of the problem; (b) the frequency of occurrence; and (c) the solutions/or suggestions.
5) Over the past five years, what has been the trend of level of resources use in your hospital? [an increase, no change, or a decrease – please estimate the percentage of change] And, what is the major reason for that trend?
6) What are your views about “instead of focusing on waste reduction, should the hospital increasing control the number of all categories of resource uses”?
7) What are the main categories of waste in your department? And how should that waste be managed?

8) Over the past five years, what has been the trend in the level of waste generated in your department? [an increase, no change, or a decrease - please estimate the percentage of change] And what is the major reason for that trend?

V) Questionnaire form for pharmacists

1) What are the main categories of pharmaceuticals and resource that your department is controlling/ using?
2) Please comment briefly about the issues below.
   (a) The re-order point
   (b) Inventory turnover (how many months?)
   (c) The selections of pharmaceuticals/inventory and suppliers
   (d) Purchasing and receiving new products
   (e) Distributing products to patients and other departments in hospital
   (f) Receiving back the left-over inventory from those departments.
3) Over the last 4-5 years, have you faced these problems: (a) shortage of pharmaceuticals/resource; (b) old/outdated stock; (c) damaged stock; and (d) long lead times?
4) From the above questions, please give details of (a) the causes of the problem; (b) the frequency of occurrence; and (c) the solutions/or suggestions.
5) Over the past five years, what has been the trend of level of resources use in your hospital? [an increase, no change, or a decrease – please estimate the percentage of change] And, what is the major reason for that trend?
6) What are your views about the ideas below?

(a) To reduce the amount of drug and medical supplies by 10% (according to the Ministry of Public Health)

(b) Instead of focusing on waste reduction, should the hospital increasing control the number of all categories of resource uses?

(c) Purchasing the products that are less toxic or toxic free

7) What are the main categories of waste in your department? And how should that waste be managed?
8) Over the past five years, what has been the trend in the level of waste generated in your department? [an increase, no change, or a decrease - please estimate the percentage of change] And what is the major reason for that trend?

VI) Questionnaire form for workers in hospital kitchen and canteen

1) What are the main categories of resource that your department is controlling/ using?
2) Please tell about purchasing process?
3) Have you selected the food materials that are locally produced and/or organic?
4) Please describe briefly about you department's daily operation regarding to preparing and distributing foods?
5) How to deal with left-over foods from those departments?
6) Over the past five years, what has been the trend of level of (a) resources used and (b) waste generated in your department? [an increase, no change, or a decrease – please estimate the percentage of change] And, what is the major reason for that trend?
7) What are the main categories of waste in your department? And how should that waste be managed?

VII) Questionnaire form for physicians and/or nurses in wards

1) Can you briefly explain your daily operations?
2) What are the main categories of inventory that your department controls/uses?
3) How do you know when to re-order or request these inventories, and in what amount?
4) What will you do if the amount of received inventory is greater or lower than the requisition?

5) Please describe briefly about the processes of purchasing and receiving new products
6) Can you give the ways to use resource efficiently and to reduce levels of waste?
7) What are the main categories of waste in your department? And, how are those wastes managed?
8) Over the past five years, what are the trends in level of (a) resource used and (b) waste generated in your wards? [an increase, no change or a decrease – please estimate the percentage of change] And, what are the major reasons for these trends?
9) Is there any problem in controlling inventory and waste? What are they, and their solutions?

VIII) Questionnaire form for laboratory technologists

1) Can you briefly explain your daily operations?
2) What are the main categories of inventory that your department controls/uses?
3) How do you know when to re-order or request these inventories, and in what amount?
4) What will you do if the amount of received inventory is greater or lower than the requisition?
5) Please describe briefly about the processes of purchasing and receiving new products
6) Can you give the ways to use resource efficiently and to reduce levels of waste?
7) What are the main categories of waste in your department? And, how are those wastes managed?
8) Over the past five years, what are the trends in level of (a) resource used and (b) waste generated in your department? [an increase, no change or a decrease – please estimate the percentage of change] And, what are the major reasons for these trends?

9) Is there any problem in controlling inventory and waste? What are they, and their solutions?

IX) Questionnaire form for administrative officers

1) Can you briefly explain your daily operations?
2) What are the main categories of inventory that your department controls/uses?
3) How do you know when to re-order or request these inventories, and in what amount?
4) What will you do if the amount of received inventory is greater or lower than the requisition?
5) Please describe briefly about the processes of purchasing and receiving new products
6) Can you give the ways to use resource efficiently and to reduce levels of waste?
7) What are the main categories of waste in your department? And, how are those wastes managed?
8) Over the past five years, what are the trends in level of (a) resource used and (b) waste generated in your department? [an increase, no change or a decrease – please estimate the percentage of change] And, what are the major reasons for these trends?
9) Is there any problem in controlling inventory and waste? What are they, and their solutions?

X) Questionnaire form for workers in laundry services

1) What are the main categories of your department's inventory?
2) Can you explain briefly your department's daily operations?
   (a) The names of the departments from which you collect garments
   (b) The frequency of collection and the transportation used
   (c) The amounts of collected garments
   (d) The cleaning process and quality control

(e) The distribution of clean garments and their amounts

3) What is the useful life of these main inventories?
4) And, generally does the hospital discard them before or after their useful life? What are the reasons?
5) If the inventories are damaged, how are they fixed or repaired?
6) Please explain the process of purchase requisition and the receiving of new products in your department?
7) What are the main wastes in your department? And how are they managed?
8) Over the past five years, what are the trends in levels of (a) resource used and (b) waste generated in your department? [an increase, no change or a decrease – please estimate the percentage of change] And, what are the major reasons for these trends?

XI) Questionnaire form for workers in central distribution unit

1) What are the main categories of your department's inventory?
2) Can you explain briefly your department's daily operations?
   (a) The names of the departments from which you collect the reusable medical equipment
   (b) The frequency of collection and the transportation used
   (c) The amounts of collected reusable medical equipment
   (d) The cleaning process and quality control
   (e) The distribution of clean reusable medical equipment and their amounts
3) What is the useful life of these inventories?
4) And, generally does the hospital discard them before or after their useful life? What are the reasons?
5) If the inventories are damaged, how are they fixed or repaired?
6) Please explain the process of purchase requisition and the receiving of new products in your department?
7) What are the main wastes in your department? And how are they managed?

8) Over the past five years, what are the trends in levels of (a) resource used and (b) waste generated in your department? [an increase, no change or a decrease – please estimate the percentage of change] And, what are the major reasons for these trends?

XII) Questionnaire form for housekeeping workers

1) Can you explain briefly your department's daily operations?
   (a) The names of departments from which you collect waste
   (b) The main categories of waste from these departments
   (c) The frequency of collection and collecting processes
   (d) Your dressing and protections
   (e) The transportation route inside hospital and vehicle
   (f) The waste storage room for general waste and other types of waste
   (g) The method for disposal of each category of waste.
2) Please estimate the percentage of the waste collected is properly sorted? If it is not sorted, how is it managed?
3) Does your hospital provide waste handling guideline? What is it about?
4) If the hospital uses the service of the 3rd party waste collectors, what are the criteria for their selection? And how is their performance monitored?
5) If the hospital uses its own incinerator to burn the waste, please explain the operating process.
6) In your view, is there an important issue about waste management in hospitals? And can you give the proper solutions?
7) Over the past five years, what has been the trend in the level of waste in your hospital? [an increase, no change, or a decrease – please estimate the percentage of change] And, what is the major reason for this trend?
8) How much does the hospital green policy affect the level of waste? Please rate the percentages, and give the reasons.

Appendix 7: Interview Form

Interview Form

Name of Interviewee: ____

Position: ______________________ Department: _______________________

Working Experience: _________ Years Tel: _________________________

Date of Interview: ______________ Duration of Interview: _______________

Interview Information:

Appendix 8: List of People Interviewed

Summarized Information of Interviewees.

Item (Number)	A	B	C	D	E	F
1. Director	1	1	1	1	1	1
2. Head Department	5	9	6	6	10	9
3. Officer	4	4	4	3	-	2
4. Worker	5	4	6	2	1	1
5. Female	13	12	12	8	6	7
6. Male	3	6	5	4	6	6
7. Average working experience (year)	N/A	19.5	8	12.7	17.2	15.9

1. A Hospital

Date	Time	Duration	Interviewee
Day 1	12.30-13.30	60 minutes	1. Administrative Officers
	13.45-14.10	25 minutes	2. Member of Env Team
	14.30-14.50	20 minutes	3. Worker in laundry
	15.00-15.30	30 minutes	4. Head of Administrative Department (Also work as Head of Env Team)
	15.35-15.55	20 minutes	5. Head of housekeeping
	16.15-16.25	25 minutes	6. Worker in Central Sterilisation Unit
Day 2	10.45-12.00	75 minutes	7. Worker producing EM
	13.25-14.50	85 minutes	8. Head of Medical Supply and Equipment Department
	15.15-16.00	45 minutes	9. Pharmacist
	16.05-16.30	25 minutes	10. Worker in Maintenance Office
Day 3	09.00-09.20	20 minutes	11. Housekeeping worker
	9.30-10.25	55 minutes	12. Nurse in Paediatrics Ward
	10.35-11.20	45 minutes	13. Head of Laboratory
	11.30-12.25	55 minutes	14. The director (1st round)
	16.05-16.40	35 minutes	15. Dental nurse
Day 4	09.00-09.45	45 minutes	16. Head of IC Department[9] (Also work in Env Team)
	16.30-17.00	30 minutes	17. The Director (2nd round)

2. B Hospital

Date	Time	Duration	Interviewee
Day 1	09.30–10.45	75 minutes	1. The Director (1st round)
	11.30-12.00	30 minutes	2. Housekeeper

[9] Infection Control Department

Date	Time	Duration	Interviewee
	13.10-13.55	45 minutes	3. Head of Administrative Office
	14.10-14.55	45 minutes	4. Head of Kitchen
	16.35-16.45	10 minutes	5. Plumber
Day 2	09.05-10.15	70 minutes	6. Head of Pharmacy Department
	10.30-11.00	30 minutes	7. Head of IPD Wards
	11.15-11.40	25 minutes	8. Worker in Maintenance Office
	11.50-12.10	20 minutes	9.Head of Thai Traditional Medicine
	13.10-13.25	15 minutes	10.Gardener
	15.05–15.45	40 minutes	11.Pharmacist
Day 3	08.55-09.30	35 minutes	12.Pharmacist
	09.45-10.10	25 minutes	13. Nurse in IPD Ward
	10.20-11.00	40 minutes	14. Head of Central Sterilisation Unit
	11.05-11.45	40 minutes	15. Head of Laboratory
	13.10-14.05	55 minutes	16. Head of IC Department
	15.30-15.55	25 minutes	17. Head of Energy Saving Team
Day 4	09.20-09.50	40 minutes	18. Purchasing officer
	10.15-11.00	45 minutes	19. The Director (2^{nd} round)

3. C Hospital

Date	Time	Duration	Interviewee
Day 1	09.45–10.05	20 minutes	1. Environment Officer
	10.05-10.25	15 minutes	2. Gardener
	10.25-11.00	35 minutes	3. Head Gardener
	11.10-12.00	50 minutes	4. Gardener
	13.20-13.45	25 minutes	5. Head of Laboratory
	13.50-14.20	30 minutes	6. Head of Central Sterilisation Unit
	14.20-15.00	40 minutes	7. Administrative Officer
Day 2	09.00-09.30	30 minutes	8. Housekeeper
	09.45-10.35	50 minutes	9. Head of Maintenance Office
	10.45-11.00	15 minutes	10. Deputy Chef of Pharmacy Department
	14.05-14.45	40 minutes	11.Head of Kitchen
	16.15-16.45	30 minutes	12.Pharmacist
Day 3	09.30-10.30	60 minutes	13.Env Team
	11.00-11.35	35 minutes	14.Vendor in Green Market
	14.15-15.20	65 minutes	15. Pharmacist
Day 4	09.15-10.20	65 minutes	16. Head of Env Team
	10.30-11.00	30 minutes	17. Deputy Director of Administration

4. D Hospital

Date	Time	Duration	Interviewee
Day 1	10.30-11.20	50 minutes	1. The Director
	13.20-14.00	40 minutes	2. Head of Kitchen

Date	Time	Duration	Interviewee
	14.05-15.00	55 minutes	3.Head of Laundry and Central Sterilisation Unit
	15.15-15.50	35 minutes	4.Worker in Laundry
Day 2	09.10-10.15	65 minutes	5.Head of Maintenance Office
	10.40-11.10	30 minutes	6.Head of housekeeper
	11.35-11.55	20 minutes	7.Gardener
	13.55-14.20	25 minutes	8.Head of Office Supplies
	14.45-15.30	45 minutes	9.Head of Laboratory
	15.55-16.15	20 minutes	10.Head of Ward
Day 3	09.20-09.45	25 minutes	11.Public Health Officer
	10.35-12.00	85 minutes	12.Head of Pharmacist

5. E Hospital

Date	Time	Duration	Interviewee
Day 1	10.00-10.45	45 minutes	1. Head of Laboratory
	10.50-11.10	20 minutes	2.Gardener
	11.15-12.30	75 minutes	3. Head of Maintenance Office
	13.55-14.40	45 minutes	4. Head of Pharmacy Department
	15.30-16.00	30 minutes	5. Head of Supply
Day 2	09.35-10.10	35 minutes	6. Head of Central Sterilisation Unit
	10.15-10.35	20 minutes	7. Head of Laundry
	11.00-11.30	30 minutes	8. Head of Waste Water Treatment and Waste Handling
	13.55-14.20	25 minutes	9. Head of OPD
	14.40-15.05	25 minutes	9. Head of Housekeeping
Day 3	09.15-10.05	50 minutes	10.Head of Kitchen
Day 4	13.45-15.00	75 minutes	11. Deputy of Director in Administration

6. F Hospital

Date	Time	Duration	Interviewee
Day 1	13.45-14.10	25 minutes	1. The Director (1st round)
	15.05-15.45	30 minutes	2. Head of Laundry
	16.20-16.45	25 minutes	3. Head of Env Team
Day 2	09.20-09.55	35 minutes	4. Head of Maintenance Office
	10.15-10.40	35 minutes	5. Head of Administration Office
	10.50-11.15	25 minutes	6. Purchasing Officer
	13.30-14.00	30 minutes	7. Housekeeper
	15.00-15.45	45 minutes	8. Head of Central Sterilisation Unit
Day 3	10.15-10.25	10 minutes	9. Head of Gardening
	11.05-11.55	50 minutes	10.Head of Pharmacy
	14.00-14.30	25 minutes	11.Head of OPD
	14.45-15.15	30 minutes	12.Doctor
	16.00-16.35	35 minutes	13. Head of Laboratory
Day 4	11.40-11.55	15 minutes	14. The Director (2nd round)

Appendix 9: List of Documents Obtained

1. A Hospital

Item	Document Obtained	Source of Document
1.	Hospital profile report	IC Department
2.	Volumes of medical supplies and equipment years 2010-2013	Medical Supplies and Equipment Department
3.	Volumes of drugs years 2010-2013	Pharmacy Department
4.	Financial reports and footnotes years 2010-2013	Administrative Department
5.	HA report year 2013	Env Team
6.	Waste handling guideline and hospital floor plan	Env Team
7.	Environmental management presentation	IC Department
8.	Clean technology EM production year 2008	IC Department and EM producer
9.	Saving energy measures	IC Department
10.	Volumes of Infectious Waste year 2010 – 2013	IC Department
11.	HA presentation (Environmental Management)	Env Team
12.	Purchasing processes and purchasing requisition form	Administrative Department
13.	Maintenance requisition form	Maintenance Office
14.	Statistics of linens cleaned	Laundry
15.	Volumes of equipment purchased	Administrative Department

2. B Hospital

Item	Document Obtained	Source of Document
1.	Hospital annual report years 2010-2013	Medical Record Department
2.	The presentation of pharmacy and therapeutic committees (PTC) (year 2012)	Pharmacy Department
3.	Foods Oder	Nutrition Department
4.	Requisition forms of chemical solutions and scientific materials	Medical Technology Department
5.	Waste volumes years 2011-2013: infectious waste and recyclable waste	IC Department
6.	Records of recycling bank	IC Department
7.	Hospital occupational, safety and environment policy	Administrative Department
8.	Purchasing guideline of the Prime Minister's Office	Purchasing Officer
9.	Hospital purchasing guideline	Purchasing Officer
10.	Financial report years 2010 - 2013	Administrative Department

3. C Hospital

Item	Document Obtained	Source of Document
1.	The report applying for Eco Hospital Award	Library
2.	GREEN and CLEAN manuals of the Department of Health	Env Team
3.	Financial report years 2011-2013	Env Team
4.	Waste volumes years 2009-2013	Env Team
5.	Brochure of hospital green practices	Env Team
6.	Volumes of utilities, waste and office supply	Env Team
7.	The operations of carbon footprint	Env Team
8.	GREEN and CLEAN presentation	Env Team
9.	Hospital Profile	Env Team
10.	Global warming reduction project	Env Team
11.	Garbage bank operations	Env Team
12.	The introduction of “C” Hospital	Env Team
13.	Ecological hospital	Env Team

4. D Hospital

Item	Document Obtained	Source of Document
1.	Pieces of annual report year 2013	QC Department[10]
2.	Medicine reducing policy (year 2013-2014)	Pharmacy Department
3.	Volumes of waste, utilities, and carbon footprint	QC Department
4.	An evaluation of environmental performance	QC Department
5.	Volumes of medicine, and returned medicines (year 2010)	Pharmacy Department
6.	GREEN and CLEAN presentation (year 2013)	Pharmacy Department
7.	Waste handling guideline	QC Department
8.	Purchasing and inventory control guideline	Head of Office Supplies
9.	Stock card of housework supply	Head of Office Supplies
10.	Footnotes of financial report year 2010-2013	QC Department
12.	Guideline of cleaning medical devices	Central Sterilisation Unit
13.	Guideline of cleaning linens	Laundry
14.	Guideline of foods production	Kitchen
15.	Food orders	Kitchen
16.	Record of cleaned linens and distribution	Laundry
17.	Record of cleaned medical devices	Central Sterilisation Unit

[10] Quality Control Department

5. E Hospital

Item	Document Obtained	Source of Document
1.	Manual of energy saving practices	Head of Maintenance Office
2.	Presentation of energy saving management	Head of Maintenance Office
3.	Retirement book of previous hospital director	Staff working in the Library
4.	Annual report years 2010 – 2011	Note taking from Library

6. F Hospital

Item	Document Obtained	Source of Document
1.	Report for HA Re-Accreditation II (January 2014)	The Quality Centre
2.	Volumes of inpatients and outpatients (handwriting)	Health Insurance Office
3.	Summary of OPD and IPD costs (1 page)	The Director
4.	Presentation for HA Re-Accreditation II	Head of Env Team
5.	Management of used linens	Laundry
6.	Transportation routes of used medical devices, used linens and waste	The Quality Centre
7.	Waste volumes years 2010-2013	The Quality Centre
8.	Report of increasing medicines usage in the first quarter of year 2014	Pharmacy Department
9.	Financial reports and footnotes years 2010-2013	Administrative Department
10.	The volume used of office supply and housework supply year 2012-2013	Administrative Department
11.	Green hospital (written by the Director in 2010)	The Director
12.	Guideline of hospital unit cost by Office of Permanent Secretary (MOPH)	Administrative Department

Appendix 10: Hospital Statistical Data

1. A Hospital

Data	Year 2010	Year 2011	Year 2012	Year 2013
No. of New Outpatients	40,660	42,816	23,612	49,291
No. of Outpatients (time)	148,538	152,617	128,035	181,058
No. of Inpatients	4,564	4,356	3,860	3,271
No. of Inpatients (night)	14,325	13,074	13,310	15,804

Item	Year 2010	Year 2011	Year 2012	Year 2013
1.Infectious Waste Volume	9,432.00	9,975.00	11,813.00	12,201.00
2.Disposal Cost	84,888.00	89,775.00	106,317.0	109,809.0
3.Transportation Cost	14,148.00	14,962.50	17,719.50	18,301.50
4.Disposal Cost (Baht)	*98,856.00*	*104,737.5*	*124,036.5*	*128,110.5*

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Profit and Loss				
1.1 Revenues	112,602,1	96,772,50	104,018,6	142,408,0
1.2 Expenses	119,391,9	99,661,76	110,763,8	122,812,8
1.3 Profit/Loss	**-**	**-**	**-**	***19,595,17***
2. Expense				
2.1 Electricity	2,229,086	2,103,557	2,552,329	3,179,763
2.2 Water	625,329.9	354,135.5	298,072.3	375,371.2
2.3 Telephone Bill	102,352.2	111,592.7	111,973.2	103,678.8
2.4 Cleaning Service	562,106.8	576,000.0	813,960.0	807,722.0
2.5 Catering	963,720.0	947,050.0	936,315.0	968,735.0
2.6 Collecting Waste	109,666.5	106,152.0	138,772.5	122,677.5
2.7 Pharmaceuticals[11]	8,593,101	9,427,086	9,055,277	10,483,85
2.8 Medical Supply	2,561,727	2,979,360	2,767,523	3,158,908
2.9 Scientific Supply	4,662,898	5,502,356	5,122,468	6,061,803
2.10 Office Supply	517,716.9	469,343.7	403,469.6	702,942.2
2.11 Computer Supply	482,784.8	830,281.5	529,954.7	517,919.2
2.12 Housework Supply	472,838.7	537,174.8	661,968.6	564,384.7
2.13 Linen	139,140.0	7,800.00	135,336.0	190,559.5

[11] Pharmaceuticals and medical supplies were classified into four main categories: (1) pharmaceutical, (2) medical supply (เวชภัณฑ์ที่มิใช่ยา) (3) biomedical material (วัสดุทางการแพทย์) and (4) scientific supply (วัสดุวิทยาศาสตร์และการแพทย์)

2. B Hospital

Data	Year 2010	Year 2011	Year 2012	Year 2013
No. of Outpatients (case)	157,547	155,561	152,052	153,726
No. of Inpatients (case)	10,167	9,652	9,960	10,392
No. of Inpatients (night)	30,337	28,173	29,577	30,363

Item	Year 2011	Year 2012	Year 2013
1.Volume of Recyclable Waste	8,200.10	7,488.70	7,505.00
2.Revenue from Selling Recyclable	36,163.00	31,503.70	30,501.00

Item	Year 2011	Year 2012	Year 2013
1.Value of Medicine Purchased	24,283,629.	24,940,144.	N/A
2.Value of Medicine Used (Baht)	18,827,029.	24,565,936.	N/A
3.Medicine Turnover Rate (Month)	3.00	2.93	2.96
4.Medical Supply Turnover Rate	3.82	4.37	3.64

Item	Year 2011	Year 2012	Year 2013
1.Infectious Waste Volume	23,911.00	23,155.00	17,549.00
2.Disposal Cost per Kilogram	12.00	12.00	12.00 &
3.Total Disposal Cost *(Baht)*	286,932.00	277,860.00	182,580.00

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Profit and Loss				
1.1 Revenues	142,268,9	171,633,3	123,040,2	140,997,0
1.2 Expenses	130,987,3	132,733,4	145,884,5	152,932,4
1.3 Profit/Loss	***11,281,59***	***38,899,88***	**-**	**-**
2. Expense				
2.1 Electricity	2,430,488	2,675,235	2,569,495	3,660,205
2.2 Water	476,911.9	428,916.9	827,261.7	1,105,557
2.3 Telephone Bill	109,039.6	150,784.5	152,431.7	136,677.3
2.4 Fuels and Energy	1,250,817	1,414,822	1,379,137	1,144,027
2.5 Cleaning Service	600,000.0	550,000.0	910,150.0	1,100,000
2.6 Catering	1,899,655	1,733,858	208,595.0	1,868,235
2.7 Collecting Waste	278,068.0	342,636.0	343,464.0	237,696.0
2.8 Pharmaceuticals	11,801,38	12,292,44	13,326,70	19,241,33
2.9 Medical Supply	1,472,713	1,709,511	2,460,953	3,630,864
2.10 Biomedical Material	3,842,351	4,237,181	4.692,133	3,030,796
2.11 Scientific Supply	7,501,765	7,938,249	8,948,514	9,028,965
2.12 Office Supply	552,683.9	783,209.2	1,131,722	1,732,375
2.13 Computer Supply	584,365.5	642,259.5	486,215.0	321,833.3
2.14 Housework Supply	2,096,344	2,184,921	3,150,241	2,277,702
2.15 Linen	39,234.15	9,600.00	106,253.0	0.00
2.16 Lab Test	3,066,362	2,816,502	3,026,497	2,318,642
2.17 Building Maintenance	2,129,715	1,994,384	7,397,500	2,173,513

3. C Hospital

Data	Year 2010 120 beds	Year 2011 150 beds	Year 2012 150 beds	Year 2013 150 beds
No. of Outpatients (case)	70,435	73,271	75,094	77,550
No. of Outpatients (time)	239,606	252,638	267,184	275,330
No. of Inpatients (case)	14,687	16,595	15,879	14,644
No. of Inpatients (night)	40,987	40,458	39,247	43,974

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Electricity				
1.1 Unit (kWh)	1,301,663	1,292,563	1,365,004	1,505,217
1.2 Baht	4,325,105	4,296,420	4,810,141	6,240,285
2. Fuels				
2.1 Litre	36,900	33,967	33,956	33,382
2.2 Baht	N/A	1,066,897	1,035,884	1,031,669
3. Waste				
3.1 General Waste (kg)	49,771	47,878	52,600	88,764
3.2 Infectious Waste (kg)	28,247	28,091	37,788	39,420
Infectious Waste	335,020	280,907	377,883	394,200
3.3 Recycle Waste (kg)	20,125	30,697	23,952	14,470
Recycle Waste (Baht)	85,994	132,606	82,482	62,188
3.4 Food Waste (kg)	N/A	N/A	2,928	20,069
4. Housework Supply				
4.1 Paper (ream)	1,209	1,241	1,127	521
4.2 12 Controlled Items[12]	291,107	503,095	450,399	152,759
4.3 Cartridge	1,497,567	1,720,671	1,443,442	566,471
5. Liquid Gas (LPG)				
5.1 Tank	250	360	487	664
5.2 Kg	12,000	17,280	23,376	31,776
6. Water				
6.1 Unit	60,370	63,167	91,091	89,669
6.2 Baht	319,569	338,309	732,158	668,986
7. CO2 Emissions				
7.1 CO_2 (kg/year)	969,620	974,470	1,028,560	1,131,990
7.2 CO_2 (kg/person/year)	2.55	2.34	2.21	2.37

Items (Baht)	Year 2011	Year 2012	Year 2013
1. Electricity	4,248,027.45	4,804,639.80	5,877,255.00
2. Water	277,921.80	833,512.31	686,868.48
3. Telephone Bill	191,736.20	342,240.40	309,315.40
4. Fuels and Energy	1,801,333.08	1,478,425.98	1,927,778.92
5. Cleaning Service	N/A	N/A	N/A

[12] The controlled items are including paper, cartridge, tissue paper, marker, liquid paper, dishwashing liquid, washing powder, battery, plastic bag, pen and slippers

Items (Baht)	Year 2011	Year 2012	Year 2013
6. Catering	2,396,900.00	2,976,453.00	3,214,900.00
7. Collecting Waste	313,210.00	377,680.80	517,770.00
8. Pharmaceuticals	27,163,787.4	19,717,128.1	31,223,061.7
9. Medical Supply	11,816,202.2	16,198,543.4	19,761,303.1
10. Biomedical Material	7,413,973.80	3,716,369.30	4,938,090.71
11. Scientific Supply	12,120,706.9	7,995,331.00	11,574,414.8
12. Office Supply	3,203,557.74	1,407,861.04	2,166,267.60
13. Computer Supply	1,632,611.00	919,258.00	1,699,165.00
14. Housework Supply	2,957,121.51	2,929,977.54	3,791,535.86
15. Linen	615,715.00	841,475.00	625,320.00
16. Lab Test	2,262,924.80	N/A	N/A
17. Building Maintenance	1,584,995.00	1,453,935.30	1,349,009.00

4. D Hospital

Data	Year 2010	Year 2011	Year 2012	Year 2013
No. of Outpatients/day	26	163	172	178
No. of Outpatients in district	76.71	70.15	71.83	73.02
Bed Occupancy Rate	N/A	62.16	56.39	60.38

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Waste				
1.1 General Waste (kg)	N/A	N/A	5,819	6,914
1.2 Infectious Waste (kg)	3,601	5,458	4,712	4,412
Weight increase/decrease	*N/A*	*+1,857*	*-746*	*-300*
Infectious Waste (Baht)	43,212	65,496	56,544	52,944
Cost increase/decrease	*N/A*	*+22,284*	*-8,952*	*-3,600*
1.3 Food waste for EM	N/A	N/A	3,050	3,600
Food waste for Biogas (kg)	N/A	N/A	5,292	4,800
Food waste for Feeding	N/A	N/A	3.,600	3,840
2. Energy, Electricity and				
2.1 Liquid Gas (LPG)	N/A	N/A	430	660
2.2 Diesel Fuels (litre)	N/A	N/A	15,116	13,564
2.3 Patrol (Gasoline)	N/A	N/A	330	1,021
2.4 Electricity (KWh)	N/A	N/A	334,319	328,851
2.5 Water (unit)	N/A	N/A	10,190	17,784
3. Carbon Emissions	**192.75**	**182.93**	**N/A**	**N/A**
4. The Accuracy of Waste Sorted	**N/A**	**91.43**	**99.27**	**98.77**

Types of Recyclable	Year 2010	Year 2011
1. Cardboard (kg)	948	898
2. Paper (kg)	390	662
3. Glass Bottle (kg)	500	732
4. Plastic Bottle (kg)	300	659

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Profit and Loss				
1.1 Revenue	50,470,16	68,401,59	59,734,75	74,990,16
1.2 Expense	54,021,09	57,431,44	60,138,61	70,458,84
1.3 Profit/Loss	-	10,970,15	-	4,531,318
2. Expense				
2.1 Electricity	784,219.6	886,565.1	1,232,097	1,551,174
2.2 Water	N/A	N/A	N/A	N/A
2.3 Telephone Bill	37,767.30	60,545.45	60,545.45	59,229.35
2.4 Fuels and Energy	N/A	N/A	N/A	N/A
2.5 Cleaning Service	337,308.6	337,327.0	576,405.0	705,999.9
2.6 Catering	N/A	N/A	N/A	N/A
2.7 Collecting Waste	48,538.06	28,000.00	61,536.00	66,348.00
2.8 Pharmaceuticals	1,226,028	1,617,838	940,974.5	887,629.2
2.9 Medical Supply	311,246.7	714,059.3	885,755.1	492,327.9
2.10 Biomedical Material	146,745.9	267,587.8	354,158.8	211,871.0
2.11 Scientific Supply	N/A	N/A	N/A	N/A
2.12 Office Supply	95,120.18	109,683.6	108,876.5	76,516.12
2.13 Computer Supply	N/A	N/A	N/A	N/A
2.14 Housework Supply	62,548.00	82,671.62	82,376.68	75,871.50
2.15 Garment	N/A	N/A	N/A	N/A
2.16 Lab Test	358,695.3	771,352.1	1,017,507	891,900.2
2.17 Building Maintenance	1,033,180	1,820,538	1,191,380	1,024,058

5. E Hospital

Data	Year 2011	Year 2012	Year 2013	Year 2014
No. of Outpatients (visit)	345,180	272,468	341,997	357,079
No. of Inpatients (night)	189,753	136,181	164,995	182,783
Bed Occupancy Rate (%)	92.00%	82.00%	82.00%	89.00%

Items	Saving Results		Investment	
Lighting	**Kwh/year**	**Baht/year**	**Baht**	**Payback (yr)**
1. Reduce needless light bulb	142,533.96	490,316.82	6,000	0.01
2. Pull switch lighting	13,826.74	47,563.99	32,060	0.67
Air Conditioning				
3. Control air conditioning system (Inpatient)	119,414.13	410,784.61	88,090	0.21
4. Control air conditioning system (OPD1-2, EENY, and Dispensary1-2)	67,285.36	231,416.64	109,760	0.47

Electricity				
5. Implement speed controller of boiler	2,759.40	9,492.34	20,000	2.11
Heating				
6. Replace diesel fuel with LPG for boiler	-	3,276,816.00	786,599	0.24
7. Produce biofuel from food waste	-	408,662.00	1,310,750	3.21
8. Reuse hot water for the boiler	-	3,000.00	4,276	0.07
Overall System				
9. Establish 'Energy Management System'	1,800.00	264,042.00	1,800,000	6.81

Type of Waste	Year 2010	Year 2011	Year 2012	Year 2013
Infectious Waste (kg)	139,621	139,555	146,594	181,443

Items (Baht)	Year 2009	Year 2010	Year 2011
1. Profit and Loss			
1.1 Revenues	645,457,070.	656,732,116.	424,785,736.
1.2 Expenses	563,666,072.	689,086,099.	424,722,777.
1.3 Profit/Loss	***81,790,998.3***	**-**	***62,959.28***
2. Expense			
2.1 Supply	N/A	56,782,944.9	50,770,512.9
2.2 Expenses	N/A	28,544,005.6	25,960,729.6
2.3 Utilities	N/A	10,701,903.0	14,802,281.6
2.4 Equipment	N/A	30,398,630.8	36,580,678.2
2.5 Miscellaneous Expense	N/A	92,544,870.8	152,717,015.
2.6 Pharmaceuticals	112,341,913.	121,687,457.	114,092,208.
2.7 Medical Supply	21,327,171.0	23,409,940.6	21,304,781.7
2.8 Biomedical Material	21,370,510.9	25,900,202.5	36,750,929.9
2.9 Lab Test	7,347,423.91	8,809,244.06	4,496,246.29

6. F Hospital

Data	Year 2010	Year 2011	Year 2012	Year 2013
No. of Outpatients	81,523	83,344	80,649	84,863
No. of Inpatients (case)	2,537	2,559	2,307	2,353
No. of Inpatients (night)	7,793	8,333	7,814	6,868

Type of Waste	Year 2010	Year 2011	Year 2012	Year 2013
Infectious Waste (kg)	6,284	6,722	8,546	7,712
Infectious Waste (Baht)	63,598	67,220	85,460	58,000
Recyclable Waste Sold	13,939	24,086	16,436	21,384

Items (Baht)	Year 2010	Year 2011	Year 2012	Year 2013
1. Profit and Loss				
1.1 Revenues	91,134,200.	85,491,04	100,711,6	92,178,23
1.2 Expenses	82,885,585.	87,623,33	89,250,39	90,841,96
1.3 Profit/Loss	***8,248,614.9***	***-***	***11,461,27***	***1,336,274.***
2. Expense				
2.1 Maintenance	2,756,154.3	2,602,925.	2,220,575.	2,410,187.
2.2 Electricity	1,863,999.6	1,725,923.	1,891,454.	2,375,560.
2.3 Water	337,700.23	272,890.4	399,903.7	568,792.3
2.4 Telephone Bill	103,829.89	173,853.8	113,088.4	130,172.4
2.5 Fuels and Energy	382,125.31	584,766.2	644,376.7	477,485.2
2.6 Catering	N/A	579,840.0	494,382	468,320.0
2.7 IW Handling	N/A	82,360.00	85,050.00	66,900.00
2.8 Lab Test	N/A	65,014.00	386,596.0	413,277.0
2.9 Pharmaceuticals	11,078,574.	9,634,563.	7,922,276.	8,626,425.
2.10 Medical Supply	1,198,027.9	2,021,880.	1,958,965.	1,092,946.
2.11 Biomedical Material	393,428.00	536,643.0	346,877.0	907,543.8
2.12 Scientific Supply	2,522,751.0	3,908,179.	4,124,572.	2,756,955.
2.13 Office Supply	500,030.84	646,354.1	525,017.3	360,841.1
2.14 Computer Supply	232,783.50	597,719.9	289,897.2	192,833.0
2.15 Housework Supply	234,503.50	504,402.0	394,638.9	161,572.9
2.16 Linen	101,000.00	24,600.00	44,790.00	206,903.7
2.17 Building Maintenance	101,503.47	109,880.00	202,269.90	169,522.17